An exploration of feelings, memory and time in the mathematical education of pupils with special educational needs, including mathematical learning difficulties

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An Exploration of Feelings, Memory and Time

in the

Mathematical Education of Pupils with Special Educational Needs, including

Mathematical Learning Difficulties

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ABSTRACT

The progress in maths of pupils with Special Educational Needs (SEN) has been shown in government statistics to be slower than that in literacy. In this context, this thesis sets out to examine how the experiences, beliefs and feelings of teachers and support assistants influence their choices and perspectives on teaching and supporting the mathematics learning of pupils with difficulties in appropriating mathematical knowledge. It also explores the experiences, beliefs and feelings about mathematics of pupils with SEN

To situate the study, a background to research into the mathematical development of pupils with SEN is presented, along with considerations of the biological and cultural factors that influence their learning processes, informed by aspects of Vygotsky's theory of human cultural and bio-social development. With this background in mind, interviews were conducted in a primary school with three groups of participants: 7 teachers, 6 learning support assistants and 6 pupils aged 9 – 11 years, with persistent mathematical difficulties, who have been identified as having SEN.

The interview data was organised using an analytical lens also inspired by the Vygotskian approach, around three themes that differently characterised the experiences of participants from each group: feelings, memory and time. Factors that impacted positively and negatively on the participation of the pupils with SEN in mathematical activities were identified within each theme.

The data shows how tools, assessment practices and curriculum constraints differently mediate the experience of learning mathematics and in particular enable the identification of strategies which did or could contribute to more positive mathematical learning experiences for those with particular difficulties in appropriating mathematical concepts.

GLOSSARY

Definition of SEN terms

I have used technical terms related to SEN education which I define in the table below. Some of these definitions are open to interpretation; however, as it is not the purpose of my research to investigate these in detail, I have given the definitions I use when referring to these terms within this paper.

TERM	DEFINITION
ADHD	Attention Deficit Hyperactivity Disorder, a condition that affects the ability to concentrate, stay on task and control behaviour. It can affect a pupil's ability to access education. It is diagnosed as a medical condition
Cognition	The process of learning
Differentiation	Teaching the school curriculum at a level that is accessible to the pupil in terms of his/her present level of performance and understanding
Developmental Language Disorder (DLD)	Children and young people with difficulties in communication. This can include difficulties with speech, understanding language, being able to express what they want to say and/or understanding the social conventions of communication.
Dyslexia	Dyslexia is a specific learning difficulty that mainly affects the development of literacy and language related skills
Dyspraxia	A difficulty with co-ordination of fine and/or gross motor skills, that can affect speaking, writing, understanding of maps, charts and diagrams, and planning and organisation.
Educational Psychologist (EP)	A person qualified in the psychological aspects of pupils' learning, particularly those who have difficulties in learning, this includes: environmental factors, cognition, behaviour, assessment and educational advice. The EP's advice is given to schools to help teachers support pupils and to give evidence towards statements of SEN or Education, Health and Care Plans.
EHCP	Education, Health and Care Plan: a plan which is in a transitional phase of superseding the Statement of Special Educational Needs (see below). It came into force September 1st 2015, and creates a template for combining education, health and social care into one plan for pupils with a variety of needs and disabilities.
IEPs	Written descriptions of the ways in which an educational setting is making provision for the individual learning needs of pupils with SEN, through targets and intervention programmes. The targets and provisions are different from and additional to their mainstream peers.
Inclusive	An educational setting which caters for all levels of ability and educational need, and where pupils with SEN are educated with their mainstream peers. In these settings the teacher is expected to differentiate according to pupil needs.
Long term memory	Is concerned with storing knowledge that requires more permanency, for instance times-tables, days of the week, months of the year.
Oral Language Modifier	An oral language modifier has been trained and is qualified to modify specified elements of language in exam papers as part of access arrangements for public exams. An oral language modifier is able to recognise and structurally alter grammatically dense sentences and replace or define non-technical language.
Resourced Provision	A setting within a mainstream school that supports, with extra resources including specialist staff and increased funding, pupils with identified SEN who require more educational support than is

	normally available within the SEN provision of a mainstream school.
SEN	Special Educational Needs (SEN) is a term used in England and Wales. It describes children and young people who require extra educational provision because they have more difficulty learning and/or accessing education than a mainstream peer. This may be owing to physical disability, learning and/or emotional difficulties.
SENCO	The Special Educational Needs Coordinator (SENCO) is a teacher who has overall responsibility for the SEN provision within school. A full description of current responsibilities can be found, DfE, 2015a , pp. 108 – 109.
SENDIST	A Tribunal where a parents/carers and young people can appeal if they are not in agreement with the provision laid out by the local authority in response to a child's or young person's SEN
Short term memory	A memory system where information that needs to be recalled for a short time is stored; consider the teacher's instructions in a classroom to 'place your books on the table, collect your equipment and then get into your groups'. The memory of the instructions needs to be held only until the actions are carried out.
Specialist teacher	A teacher with specialist knowledge of SEN who can apply specialist teaching approaches.
Speech and Language Therapist	A qualified health professional who assesses and treats people with speech, language and communication needs.
SPLD	Specific Learning Difficulties (SpLD) may affect any or a combination of memory, information processing, communication, literacy, organisation, direction, concentration, senses. Dyslexia is an example of a combination of specific learning difficulties.
Statement of SEN	A statement of SEN is being superseded by the EHCP (see above). It is a legal document that outlines the educational needs, school placement and provision to be put in place for pupils with SEN who need more support than general mainstream SEN can usually provide.
Working memory	A memory system employed when carrying out tasks by processing information from either or both long term and short term memory. For instance when carrying out a mental mathematics computation such as the number of days between August 20th and September 9th the long term memory will search for information on the sequence of months and how many days are in August, while short term memory holds the requisite dates. The information is processed in the working memory to find the solution and may also include the processing of the number of days to the end of August added to the number of days in September.

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1 INTRODUCTION

1.1 Context

My interest in teaching mathematics to pupils with Special Educational Needs (SEN) developed from working with pupils with SEN (7 – 16 years). The term SEN is taken from the UK government description of pupil characteristics (Department for Education (DfE), 2015b). I explain the change in term for mathematics difficulties used for my research on p.19. As a specialist speech, language and dyslexia teacher I have observed that many pupils, with complex SEN, have difficulties progressing with mathematics. My training, as a Specific Learning Difficulties (SpLD) teacher and assessor, focussed on teaching literacy with minimal attention paid to mathematics difficulties. However, through my teaching I became increasingly aware of the need to teach mathematics as well as literacy to many of my pupils.

My experiences whilst teaching mathematics to pupils with complex SEN, including attending training days and developing methods suited to individual learners, led me to develop two hypotheses which affected my choice of topic for research:

- The methods available for use in teaching mathematics to pupils with SEN are not as varied as those that are available for developing literacy.
- Pupils with SEN can improve their enjoyment of, understanding and performance in mathematics, if receiving informed teaching based on an understanding of the pupils' individual needs.

These hypotheses were built on my own teaching experiences and the data collected and analysed for my unpublished Institution Focused Study (IFS) (Bauer, 2013). I wanted to avoid drawing conclusions too confidently from limited data

(Kahneman, 2011,) so my aim was to explore whether data, collected from staff and pupils in a different age group than that in the IFS, following a different maths syllabus, taught within a different classroom system, would yield similar insights. If not, what new perspectives might be advanced?

1.2 Mathematical progress and attainment

In my work within a secondary mainstream school, leading a resourced provision for pupils with Developmental Language Disorders (DLD), and through independent 1:1 work, I have been increasingly asked to teach maths. Frustratingly, I found that pupils' Individual Education Plans (IEPs) were shown to me either without mathematics targets or with repeated targets such as 'learn the number bonds' and 'learn the times-tables' without any sign that the targets had been achieved. This led me to investigate mathematics outcomes for pupils who had SEN, as part of my preliminary research.

I am using the terms progress and attainment as descriptions of outcomes following set periods of maths study. Periods of study are directed by UK government policy and are described as Key Stages (KS) (Table 1-1)

Key Stage 1	5 – 7 years	Years 1 and 2
Key Stage 2	7 – 11 years	Years 3,4, 5 and 6
Key Stage 3	11-14 years	Years 7, 8, and 9
Key Stage 4	14 – 16 years	Years 14, 15 and 16

Table 1-1 Key Stages of Study

After following a statutory programme of study, The National Curriculum, in KS1 and 2, pupils are assessed in national Standard Attainment Tests (SATS). The DfE has minimum standards, for the percentage of pupils expected to meet average and higher than average attainment in every mainstream school in England, for instance in mathematics, 2017-2018, it was 65% at KS2 (DfE, 2018a).

The term 'attainment' refers to the academic level reached by a pupil against standards set by the government. The method of assessing progress by levels changed in 2016 to a scaled scoring system; however, tests and expected progress remain in place. In 2018 the average scaled score that pupils are expected to achieve is 100. They must achieve these scores in reading and mathematics (DfE, 2018a).

The results of this testing are used officially to compare schools' progress in league tables (DfE, 2018b). The consequences of a school's poor performance include teachers preferring to apply for jobs in higher ranked schools, teaching to the test to gain good results, and teaching to focus on borderline pupils, that is, those who with more input could reach the expected national standard (West, 2010).

In England, 2018, 76% of pupils achieved a standard score of 100 or above for mathematics (DfE, 2018a). However just 37% of pupils with SEN gained such scores. If a pupil had a statement of special need, or an Education Health and Care Plan (EHCP), then only 15% reached the expected standard (DfE, 2018c)

It has not yet been established what "sufficient progress" is for pupils with SEN. Butterworth and Kovas (2013) pointed out the high prevalence of co-occuring learning difficulties, for example Dyslexia with Attention Deficit Hyperactivity

Disorder (ADHD). They expressed the need for research to be carried out to ascertain whether a combination of learning difficulties will have an increased effect on attainment either 'additive or multiplicative' (ibid. p.304). Nevertheless, statistics are showing that a large proportion of pupils who experience difficulties with learning mathematics are doing so from a young age.

I began my research from the personal experience that some pupils with SEN can be taught mathematics successfully, and in some cases progress beyond expected levels, when they have initially low attainment. I decided to investigate the beliefs and experiences of staff and pupils about teaching and learning maths because they respectively deliver and receive government policy, the curriculum and pedagogical methods.

In my IFS (Bauer, 2013) I interviewed pupils and staff in a mainstream secondary school about their experiences of teaching and learning mathematics. A number of common themes emerged, suggesting that the accessibility of the curriculum and aspects of its delivery could offer areas of research related to improved progress. For this Research Based Thesis (RBT) I chose to research personal beliefs within the KS2 setting (7 to 11-year-olds). I was interested in any common or opposing experiences to my IFS which focussed on KS3 (11- 14 year-olds), and to develop any theories that might suggest that certain practices could enhance the progress of pupils with SEN who were not progressing well with mathematics, in either setting.

1.3 Mathematical learning and SEN: A descriptive term

There are two broad areas that need to be considered when analysing the use of a label to describe difficulties in learning maths: firstly, an academic debate as to whether any label serves a useful purpose, and if so, what label would be suitable. In the first instance Billington (1996) argued that diagnoses pathologise children for the purposes of benefiting institutions' economies, regulating the individual and supporting an industry which earns money through special needs support. Lauchlan and Boyle (2007) also made the case for not labelling students. They argued that labels stigmatise pupils, make the difficulty a deficit of the pupil, lower expectations, lead to low self-esteem and bullying and serve no useful purpose if the meaning of the label is unclear or an intervention is not appropriately forthcoming.

Alternatively, Bishop (2014) supported the use of labels. She argued, with regard to speech and language difficulties, that there is no universally understood label. Without one there can be no agreed criteria for inclusion within learning needs groups, no procedures for appropriate interventions, and no indication of the type and amount of intervention that should be given. She added that without a label pupils cannot gain access to interventions. For this reason she promotes the designation Developmental Language Disorders which I use in this thesis. I would also argue this same case in regard to mathematics.

As regards loss of self-esteem, this can manifest before any label is applied, when the pupil is struggling but does not understand why (Glazzard, 2010). Glazzard carried out a small-scale study of pupils diagnosed with dyslexia at two schools. The

pupils described a range of feelings such as “stupid”, “disappointed with myself”, and “like I was the only one” (pp. 64 – 65) before they were diagnosed. After diagnosis these pupils were found to describe their difficulties more knowledgeably, explaining that their brains worked differently and needed adaptations, however they no longer felt that they couldn’t learn. Frederickson (2010) found that pupils with different learning difficulties would be accepted more by their peers if they understood the pupils’ learning difficulties.

Difficulties in learning mathematics, however, are not homogeneous. An expanded discussion of this can be found in Chapter 2. Difficulties can stem from, for example, a lack of concept of number, or difficulty with remembering and recalling mathematics facts and procedures. Difficulties may also arise because of SpLDs such as dyslexia, DLD or dyspraxia.

There is no standard descriptive term for learning difficulties in mathematics. The British Dyslexia Association uses the terms dyscalculia and mathematics learning difficulties to describe a range of symptoms associated with mathematics difficulties. Butterworth (2010) used the term dyscalculia more specifically for problems where a child has not acquired the ability to enumerate sets of objects or use the operations of addition (+), subtraction (-), multiplication (x) and division (÷), which he termed ‘numerosity coding’ (p. 538). Landerl, Bevan and Butterworth (2004) used Developmental Dyscalculia (DD) to describe a specific mathematics learning disability which manifests in difficulties in learning arithmetic facts and procedures.

Mathematics Difficulties (MD) is used by some researchers (Jordan, Hanich and Kaplan, 2003, Fuchs, Powell, Seethaler, Cirino, Flewtcher, Fuchs, Hamlett, 2010). Jordan et al. (2003), using centile ranking[1], identified pupils with MD as achieving a score on the 35th centile or below in mathematics subtests on calculation, applied problems and grade-normed results. They also identified another group of pupils with MD and Reading Difficulties (MD-RD) who gained scores on the 35th centile or less in both mathematics and reading tasks. Fuchs et al. (2010) also distinguished between pupils with MD only and pupils with MD-RD, but their cut off point for MD was a centile rank below 26th, described as "below average" (p.91). They used the term MD as Mathematics Difficulties within their abstract but also wrote about pupils having "mathematics disability" (pp. 89, 90) on a seemingly interchangeable basis.

Rourke (1993), a neuropsychologist, refers to non-verbal learning disabilities and their effect on specific arithmetic disabilities, while the term Mathematical Learning Disabilities (MLD) has also been used (Desoete, Ceulemans, de Weerdt, Pieters, 2009, Geary, Hoard, Bailey, 2012). Desoete et al. used MLD to describe 3 – 14% of the population with a lack of ability in processing quantity. Geary et al. used mathematics achievement scores with 25th centile cut off point to identify pupils who started at a low assessment base and had made slow progress over time, these they described as having MLD, compared to pupils who started at an average level but made slow progress. The variety of cut-off points and terms used by

[1] A centile ranking denotes the position out of 100 pupils tested that an individual achieves, thus a grade on the 35th centile would denote that 65 out of 100 pupils would score higher. It should be noted that a score on the 16th centile or lower is accepted as being below average in the UK (NFER, 2015).

researchers suggests that learning difficulties in mathematics has not yet been defined with any agreement.

For my research purposes I argue that a label is necessary (Bellair, Clark and Lynham, 2014). I use the term Mathematics Learning Difficulties (MaLD) to encompass the children I have interviewed. They were not assessed for need, ability or attainment levels as part of the interview selection process and the label, as used, is a generic one to include all these pupils. These pupils were chosen because they have persistent difficulties with mathematics learning for a variety of reasons; and all were described as having SEN, and registered as such, within the school data. I have not used the term disability even though, with the pupils I interviewed, their mathematics difficulties could meet the disability definition of The Equality Act 2010: "'substantial'...more than minor or trivial" and "long-term" (Office for Disability Issues). My analysis of the data leads me to conclude that there could well be learning disabilities present in some of the children, but these are not necessarily disabilities specific to mathematics. Mathematics Learning Difficulties (MaLD) is used for the purpose of this research and is not intended as a definitive label for all children and young people who have difficulties learning maths.

1.4 Choosing a theoretical framework

I have chosen to locate this research within Vygotskian theories of education. A detailed discussion of this is included within the Literature Review, pp.24-45; a brief introduction is included here.

Vygotsky, a psychologist, described child and adolescent development, and theorised on education from a social-cultural perspective. He described learners as immersed in and affected by their social, cultural and historical backgrounds, to the extent that their development would be affected by adverse social-cultural conditions.

> "Since development of self-consciousness is the result mainly of social-cultural development of the personality, it is understandable that the differences in the cultural environment must also directly affect the rate of development of this higher function of personality in children living in unfavourable social-cultural conditions"
>
> (Vygotsky, 1998, p.178)

Vygotsky was interested in the education of all learners, including pupils we would now describe as having SEN (Vygotsky, 1993). His theories have been of interest to a larger educational field since his work became more widely known in Western Europe through translation. Despite his research taking place in the 1920s and early 1930s, his work continues to influence research, leading to Western neo-Vygotskyian theories on a wide range of educational topics including assessment, teaching methods, and the development of cognition.

Daniels (2001) structures his description of Vygotsky's pedagogy on the basis of the dialectical nature of his theories, that apparent opposites in fact present a united whole. The dialectical nature of Vygotskian and neo-Vygotskian theories encourages further research, for instance Bøttcher and Dammeyer (2012) investigated the differences between adult interactions with a pupil with disabilities at home and at school. They concluded that the differing environments and interactions affected how the child was responded to and perceived. They

positioned this work in relation to a mismatch between cultural expectations and the child's natural development.

1.5 Research questions

I have developed a growing interest in this field of research while working in an educational period that aims to promote inclusion as a cultural norm. The DfE (2015b) states for instance that public bodies including schools "**must** make reasonable adjustments, including the provision of auxiliary aids and services, to ensure that disabled children and young people are not at a substantial disadvantage compared to their peers" (p.17) and that such

> "principles are designed to support: .....
>
> - A focus on inclusive practice and removing barriers to learning"
>
> (ibid, pp. 19 – 20)

This led me to ask: what are these adjustments and how do we remove barriers to learning? This raises many potential areas of research. I have chosen to focus on evaluating mathematics learning in this context with the following research questions:

1. What are the feelings and beliefs about, and experiences of, mathematics education expressed by pupils with SEN and MaLD, their teachers and Learning Support Assistants?
2. What are the main factors shaping these beliefs, feelings and experiences?
3. What are the roles of tools in disrupting the course of these factors, and contributing to improving outcomes?

2 LITERATURE REVIEW

The literature review explores firstly the theories of Vygotsky in relation to SEN, concentrating on his theories on development, the significance of socially mediated signs and tools, and the influence of the environment. Finally, his interest in assessment is explained.

Secondly, I look at mathematics learning in regard to primary education. I consider the natural line of development of pupils with SEN and MaLD in relation to expected skills in mathematics. I focus on the skills of memory, conceptual understanding and language, and contrast the cultural with natural development in these key areas.

The final section examines the environment within which mathematics education is enacted. This includes the National Curriculum, the use of tools and current methods of assessment.

2.1 Vygotsky: Theory and Special Educational Needs

I shall introduce Vygotsky's theories in relation to his work on "defectology", the word used in translation (Vygotsky, 1993, p.1) for pupils we would now describe as having special educational needs (SEN). His work did not focus on all the groups now included under this term, but I will argue that it is possible to extend his ideas to these and I will favour the acronym SEN to describe the pupils Vygotsky has written about in order to follow current conventions. I also concentrate on Vygotsky's research and writing about pupils with SEN to remain in keeping with the subject of this thesis.

2.1.1 Inclusion

Vygotsky argued that having a special need isolated pupils from society, socially and culturally, by placement in a special school; a conventional, historical choice. This led to a subsequent withdrawal of the pupils from the norms of society. Children were also excluded by being viewed in terms of their SEN. The children became either a burden to society or a recipient of extra love, both of which create "social dislocation" (Vygotsky, 1993, p.76).

Vygotsky held the premise that learning is a social act and argued that it was the social effects of the special need that created difficulties for children by denying them full access to society and effectively impeding their psychological progress.

The social management of the child's development therefore was important to Vygotsky. For the purpose of this thesis I will explore two aspects of Vygotsky's theories on child development in relation to SEN. These are firstly psychological development both natural and cultural, with regard paid to memory. Secondly social mediation and his views about the role of cultural signs and tools promoting psychological development; here I will explore the use of speech, language and tools.

Following this I will look at emotions, in Vygotsky's perspective these are an effect of social structures which "invariably turns out to be secondary, rather than direct" (Vygotsky, 1993, p.35). Finally, I will introduce Vygotsky's views on assessment and its application to children with SEN.

2.1.2 Natural and Cultural Development

Vygotsky stated that we have two intertwined states of development, natural development which relies on characteristics "closely bound up with the processes of general organic growth and the maturation of the child" (Vygotsky, 1994a, p.57)[2]. Secondly cultural development which explains the progress and changes we make as we relate to our society: its norms, conventions, structures and objects. To begin, I will look at natural development, then cultural development and next their implications for pupils with SEN.

Natural development for Vygotsky begins with the biological "psychophysiological characteristics" (Vygotsky, 1993, p.167) which form the child's innate being. Our natural development facilities are of "biological evolution" (Vygotsky and Luria, 1994, p.137). These are not separate facilities; each has a connection to the whole. Thus, we have the facility of perception, we can perceive objects, people, and things, through our senses. We also have the facility of attention, here we are able to keep our perception fixed, for instance on an object, and later on the important features of that object. We also have the natural development of movement which would allow us to react physically to something we have perceived. Memory, in its natural form, allows us, to remember images and sounds and recognise them again:

> "…the widening of that fragment of the past which actually fuses in a united whole with the present"
>
> (ibid. p.133)

In their natural form these facilities allow the child to behave "in a spontaneous situation" (ibid. p.121) before she/he can control these facilities and act with them in a deliberate manner; the latter is the influence of cultural development.

[2] Currently we would also include those characteristics which change through illness or accident

The evolution of natural to cultural development, Vygotsky, reasoned, is linked indissolubly with the social (Vygotsky, 1994a). It is the culture of society, for instance, that introduces the child to language and numbers. Children learn to use cultural experiences in order to become a functioning member of their society. Cultural activities like education are part of this process. All cultural activity enhances, and works with, natural development, transforming it into more sophisticated modes.

A child who can see, may fix attention on an object, and learn to grasp for it. The object itself is a cultural artefact, already influencing the child's development. Vygotsky described how a baby grasping for an object and a mother realising and responding by giving the object, is beginning a process of communication that enables a grasping motion to become a symbolic sign (Vygotsky, 1978). Here the cultural significance of gesture and has been gained through the influence of the natural facilities of sight, movement (sensori-motor responses), attention and memory and transformed them into a more deliberate process.

Access to the semiotic and material tools of the culture a child grows up in enables the development of higher psychological functions. He described higher psychological functions as of two types. The first is the mastery of our external methods of learning and communication, for instance language, writing, reading, drawing and counting. The ability to use these methods gives the child the external means to develop and master the functions of memory, perception, attention, and movement (Vygotsky and Luria, 1994).

The second set of higher psychological processes is the development of the functions that enable us to learn, for instance: logical memory, verbal intelligence, conceptual understanding and voluntary attention (ibid. 1994). These processes allow children to progress to deliberate, planned and organised thought and actions. Vygotsky exemplified this in the development of counting whereby in early stages of development the child has an:

> *"immediate perception of given pluralities…the child does not really count but perceives quantities"*
>
> (ibid. p.139, italics Vygotsky and Luria's own)

When the child has learned speech, and the use of tools to help counting, which form our cultural means to progress in number work, there is:

> "a radical reconstruction of the participating psychological functions; calculation with the help of complex counting systems…presents a qualitatively new…specific psychological formation"
>
> (ibid. p.139)

The intertwined nature of both types of higher psychological process is important but it is also important to recognise that the forms by which they are achieved also depends on "that which was given by nature" (Vygotsky, 1994a, p.59). Moll (1994) argued that while much has been written about Vygotsky's claims about the role of culture in cognitive development, less attention has focussed on his argument that natural properties also constrain and enable the social construction of higher psychological processes.

In the typically developing child, as a result of cultural immersion, basic psychological functions take on more refined characteristics such as "voluntary" and "logical" to reflect their growing mastery of cultural tools.

However, not all children are born with the same natural facilities. They may have visual or hearing impairments, mobility challenges or "different functions of the brain" (Vygotsky.1993 p.167). These children cannot readily use, or do not possess, one or more of the natural development facilities. This can have a negative effect on the child's progress into cultural development. It is the biological difference that creates a disjunct between the child and the social and cultural practices of his/her environment. These practices cannot be accessed so readily by the child and it is this that disrupts the child's development.

> "a child with a disability differs from his peers without disabilities not only due to the biological defect but also because of the defect, and the incongruence it gives rise to makes development much more difficult for this child"
>
> (Bøttcher, L. and Dammeyer, J., 2012, p.435)

Vygotsky pointed out that culture is built upon typical psychophysiological development (Vygotsky 1993). He argued that if children had any impairment in natural development it could prevent their access to certain cultural norms and the natural development would remain static (ibid. 1993).

He stated that this is a special need that:

> "naturally disturbs the normal course of the child's acculturation. Atypical development…cannot be spontaneously and directly conditioned by culture"
>
> (ibid, 1993, p.42)

He exemplified this with the losses of the natural development of hearing and sight. For instance, a child with a hearing impairment (HI), because of his inability to hear, is unable to develop oral speech. Speech is the cultural norm for communication, and we expect it to be established through hearing and sound. The consequence of lack of hearing has a wider impact because, without hearing, speech is not

developed and the child's access to further cultural development and higher psychological processes is compromised (Vygotsky 1993).

In the case of the loss of the natural development of sight such visual activities as reading are not accomplished following typical cultural methods. If a child is unable to read, a world of ideas, imagination and intellectual thought could be beyond reach. Additionally, a child with visual impairment (VI) has difficulties in understanding concepts that need sight to support the vocabulary, for instance colours (ibid, 1993). In neither of these cases, Vygotsky argued, should we assume that the child is ineducable or does not possess the capacity to use other cultural forms. Thus, a child with VI may learn to read through Braille, and a child with a HI can use sign language and lip-reading for speech (ibid. 1993).

He argued that instead of describing such differences as defects or failures, they should be part of a complex picture of different "developmental paths" (ibid. p.169). From this position we should view the positive aspects of the child's personality as well and find alternative cultural means by which the child will be able to develop. Cultural methods and artefacts develop in society and are therefore human constructs and inventions. Vygotsky describes cultural development as "unlimited" (ibid. p.169) because it is the:

> "main area for compensation of deficiency when organic development is impossible"
>
> (ibid, p. 169)

In relation to higher psychological functions Vygotsky was concerned about both the goals and methods of teaching pupils with special needs. He argued that by creating a social and psychological pedagogy which concentrated on developing the

higher psychological functions children with SEN could learn explicitly what other children may learn naturally (Kozulin, 1990). They should also be able to access the education of their typically developing peers. Vygotsky did not claim that this development would necessarily take place at the same pace as typically attaining children, some:

> "children… display an inability to proceed in step with the rest of the children in their school studies"
>
> (Vygotsky,1993, p.182)

I understand by this that Vygotsky believes there are multiple appropriate paths and means by which children may have their difficulties in natural development bypassed. In this case we are only limited by our imaginations and our humanity.

2.1.2.1 Summary: Natural and Cultural Development

Here we have seen that in a Vygotskian view cultural development, in which education forms a part, can be compromised by impairments arising from the natural developmental facilities of a child. Society is primed to use cultural methods and means that support the typically developing child. This has the effect of isolating a child with atypical natural development from his/her society and from developing higher psychological processes. These higher psychological processes, though, have the potential to be developed.

I will now introduce briefly his theories on an area of natural and cultural development that has bearing on an aspect of mathematics education and SEN within this thesis: the skill of memory.

2.1.3 Memory

Vygotsky described memory as:

> "among the most central and basic mental functions"
>
> (Vygotsky, 1987, p.368)

He argued that in in the earliest uses of memory the child's memory is based on experience; a social/cultural interaction:

> "it is the child's experience, and the direct influence of that experience documented in memory, that define the entire structure of his thinking"
>
> (Vygotsky, 1978, p.309)

He described the development of memory as progressing in tandem with children's natural developmental facility of attention. Memory then becomes a psychological process, altered by culture, which children use in a deliberate, planned manner:

> "The child's…memory from a passive 'registrator' becomes a function of active selection and of active and intellectual recollection"
>
> (Vygotsky and Luria, 1994, p.122)

Vygotsky linked this process in memory to the use of external aids to prompt memory. Vygotsky exemplified this with adults' use of tools as memory aids such as knotted handkerchiefs or notches in sticks. He showed that children were able to use this principle, without instruction, when he gave them picture cards and lists of words to remember. The picture cards were not related to the words, but children created associations between the pictures and the words, and as a result were able to remember more than by memorising without any aids (ibid. 1994).

Memory transforms into its higher psychological functioning when it is used for thinking and logical argument. Here Vygotsky described the recall of facts, which are used to enable the structures of logical thinking:

> "…memory is logicalised to the extent that recall is reduced to establishing and providing locations for logical relationships, recall…becomes a search for points that have been established"
>
> (Vygotsky, 1987, p.309)

The recall of facts, Vygotsky pointed out relies on verbal memory or "memorizing in words" (Vygotsky, 1984, p.67). This, he argues, must precede "logical memory" (ibid.p.67). Recall becomes a means to an end, a process. Vygotsky pointed out in relation to this that memorisation functions much better when it is based on understanding:

> "No one attempts to memorize the solutions to arithmetic problems. One must understand the process involved in solving these problems only once to acquire the potential for solving them in the future"
>
> (ibid. pp.305-306)[3]

This Vygotskian view of mathematics, we will find, does not correspond with all contemporary mathematical education. To solve problems through understanding a process "only once" may be a tall order for some pupils with SEN and MaLD; however, the principal point is the importance of understanding. Speech here is also important because it combines past and present experiences in order to enable logical thought (Vygotsky and Luria, 1984).

Vygotsky noted, when he compared children with SEN to typically attaining peers that:

> "they remember differently, in a different manner, by different methods; they use memory to a different degree…the degree of development of memory is one thing, and the degree of its use quite another"
>
> (Vygotsky, 1993, p.45)

He observed that the relationships between the different natural functions and culturally developed functions do not develop in the same way as in a typically developing child. Therefore, the child needs:

[3] This may have been stated whilst considering a higher-level mathematics than the number sense that this thesis is concerned with. However primary mathematics in England currently expects memorisation of number facts (DfES, 2006) and I read this as being in support of the view that understanding should be a more favoured goal of primary mathematics education.

> "roundabout paths of development…to overcome difficulties"
>
> (ibid. p.131)

In finding these roundabout paths Vygotsky expressed the view that the child with difficulties had to be more creative and requires support through different methods:

> "the essence of direct recall becomes a process of combination, imagination, thinking and so forth"
>
> (ibid. p.128)

In this respect Vygotsky argued the importance of the development of logical memory. It is not enough to rely on visual aids as a substitute for thinking; these would leave the child with a static, natural, visual and concrete memory but an inability to progress to abstract thought. The roundabout methods and visual aids must also use visual material to enhance understanding and the development of logical memory (ibid. 1993, pp. 148-9).

2.1.3.1 Summary: Memory

We see that, from a Vygotskian perspective, memory functions develop from natural, concrete and visual images to abstract and logical thought. It is with the intertwining of other natural and culturally developed functions such as attention, and the intervention of the use of language, and auxiliary tools, that the ability to memorise progresses in typical development. Memory becomes a higher psychological function when it is used for logical thought and abstract ideas. Recall is merely a means to this end.

Vygotsky acknowledged the difficulties with memory that some children with SEN demonstrate. To counteract this Vygotsky recommended the use of visual tools, not

only to support learning, but to enhance understanding in order that these children can cultivate their higher psychological processes of memory.

I will now explore the means by which Vygotsky argued that the higher psychological processes are formed through cultural development. I will introduce his views on social mediation and then two aspects of mediation relevant to mathematics learning.

2.1.4 Social Mediation

Vygotsky argued that socially mediated activity is the external, social means through which development of the higher psychological functions takes place (Kozulin, 1990). Mediated activity is learning that is founded in interaction with society. This mediated activity can be present in the use of tools, symbols and/or the actions of other human beings (Kozulin, 1990).

From this perspective the social environment and terms of mediation in which the child with SEN is educated can have a profound bearing on his development. To meet the psychological needs of a child with SEN Vygotsky argued for:

> "special pedagogical techniques, devices and methods"
>
> (Vygotsky 1993, p.83)

Vygotsky emphasised the socially mediating effects of speech and pedagogical tools so next I explore the importance Vygotsky placed on these as mediators of higher psychological development.

2.1.4.1 Speech

In its earliest form, in young children, Vygotsky stated that speech "begins very early to fulfil intellectual functions" (Vygotsky, 1993, p.194), children are learning to express difficulties and find solutions to practical problems:

> "speech and action are in this case *one and the same complex psychological function*"
>
> (Vygotsky and Luria, 1994, italics Vygotsky and Luria's own, p.109)

Speech development advances to encompass social communication between people.

Speech heightens the development of all the higher psychological functions, including memory. At this stage speech is being used in a symbolic sense as it does not just deal with the here and now but also with imagined future or remembered past actions and situations. Vygotsky and Luria (1994) argued that at this stage

> "we find *the mastering of one's own behaviour with the assistance of symbolic stimuli"*
>
> (ibid. p.135, italics authors' own)

However, the mastery of symbolic stimuli doesn't stop at this process. Vygotsky and Luria argue that "speech lifts action to its highest stage", (p.169). The symbolic stimulus of language becomes an important element in a system of signs. These are accepted external cultural devices which help us, for instance, to use higher psychological processes such as logical memory, and to participate and communicate in society. Cultural signs include the written form of our spoken word, musical notation, graphs, tables, drawings and numbers. In a mathematical example the signs on the ruler are the numerical symbols and the language of the measuring system, for example metres, centimetres or feet and inches. When we have learned these signs, we can participate in the world of mathematical measurement.

Vygotsky considered the difficulties of children with special needs in relation to speech and language. He noted that

> "underdevelopment of speech leads to exclusion…and exclusion…stalls both social education and speech development"
>
> (Vygotsky, 1993, p.207)

As Vygotsky argued, above, speech development is an important, influential mediator in developing higher psychological functions, including logical memory. Its development influences the child's access to culture and education.

> "Signs and words serve children first and foremost as a means of social contact with other people. The cognitive and communicative functions of language then become the basis of a new and superior form of activity in children...''
>
> (Vygotsky, 1978, p.29)

The roundabout means to education, as, for example use of visual aids, are also enhanced by language:

> ''The specifically human capacity for language enables children to provide for auxiliary tools in the solution of difficult tasks..."
>
> (Vygotsky, 1978, p.29)

The use of auxiliary, pedagogical tools is the second cultural mediator in this thesis that I will relate to mathematics education.

2.1.4.2 Pedagogical Tools

When a child cannot access culture in a typical manner Vygotsky argued that we must find alternative methods to support the child's ability to access and learn from culture. These alternative methods must be:

> "…adapted to the specific psychophysiological characteristics of an abnormal child"
>
> (ibid. p.168)

He exemplified this with the use of Braille for VI, where reading becomes a system of touch, not sight.

Vygotsky viewed cultural tools as an important means of teaching children with SEN. The culturally driven aspect of child development, Vygotsky argued, required the knowledge and use of tools which have been developed by society. A tool is an object that is "externally oriented; it must lead to changes in objects" (Vygotsky, 1978, p.55), thus a pencil, ruler, children's toy bricks are tools. He argued, though, that the inception of speech in children gives them the ability to use tools in a human way that involves the intellect (Vygotsky and Luria, 1994). Thus, I could present the number-line as a tool that can enhance our perception of number, and among other things, lead to understanding of the pattern of number, the four operations, and measurement. However, the semiotic signs of language will also be needed to access for instance, the symbols on the number-line, the scale being employed and the four operations.

Vygotsky argued that the child's personality would be affected by using tools and signs, because they aided socio-cultural development. This could be particularly salient in a child with SEN; if the child is unable to use culturally typical tools and signs, this will affect his/her development.

> "The inability to use natural psychological functions and to master psychological tools... determines the kind of cultural development a handicapped child will attain''
>
> (Vygotsky, 1993, p.45)

Vygotsky contended that if pupils with SEN were given tools that were suitable for their development, they would have as much capacity to learn as pupils without SEN because they retained the psychological ability to use tools. The tools though should be appropriate to their learning needs or presented in a way that was meaningful to the child.

> ''What remains is the necessity of creating special cultural tools suitable to the psychological make-up of such a child, or of mastering common cultural forms with the help of special pedagogical methods, because the most important and decisive condition of cultural development –precisely the ability to use psychological tools- is preserved in such children''
>
> (Vygotsky, 1993, p.47)

2.1.4.3 Summary: Social Mediation

Vygotsky emphasised the importance of speech and the use of tools in socially mediated child development. Speech, and language, is an important sign in mediating the higher psychological processes, particularly of logical memory. Secondly mediating pedagogical tools can be used as auxiliary aids in the educational development of children with SEN. These tools must be appropriate to the needs of the child and consideration should be given as to their purpose: as an alternative means of access, and/or as an alternative means to understanding.

2.1.5 Emotional Experiences

The third area of interest is in emotional experiences related to the environment in which socially mediated education takes place. Vygotsky stated that we should examine the environment regarding the child's stage of development, not as the environment in general but

> "viewed in relation to the child"
>
> (Vygotsky, 1984b, p.338)

He argued this was important because changes in the child's development mean that his relationship to the environment changes. Additionally, the child's environment changes as she/he progresses, for instance, through the education system. Vygotsky pointed out that the child's emotional experiences in an environment will have impacts in two areas. One is on his emotions and resultant

behaviour, the second is the resultant possibility of a lessening of development of the higher psychological processes.

Emotions and behaviour Vygotsky linked to environmental factors by arguing that we become aware of ourselves through our social and cultural interactions (Vyogtsky, 1998). When observing children's emotions, we should consider the environment through their eyes, how they are reacting to, and interpreting events (Vygotsky, 1984b). This is because emotional responses can exert changes in the child's personality and, in addition, their development.

The environment provides, in addition, the conditions which afford the possibilities of development from the moment the child joins it (Vygotsky 1984b). He exemplified this with the learning of arithmetic where, he states, that the already formed mathematical constructs of the adults are present within the guidance given to the child's early learning. As a result, Vygotsky argues that the environment must represent all the appropriate forms and actions that the child needs to develop appropriately (ibid. 1984b).

He stated that if the environment did not meet these needs the child's development would be affected:

> "when …the interaction between the final form which exists in the environment and the rudimentary form which a child possesses, becomes disrupted, the development of the child turns out very limited"
>
> (ibid. p.351)

When Vygotsky pointed out that:

> "the child is not directly aware of his handicap. Instead, he is aware of the difficulties deriving from the defect."
>
> (Vygotsky, 1993, p. 35)

He was referring to the difficulties, and resultant lowered social standing, that the child encounters and reacts to within his environment. Here the environment in which the child feels isolated or excluded may have further effects on the child in terms of emotional responses and behaviour.

Vygotsky described this position in the environment as invoking feelings of inferiority. In these cases:

> "what decides the fate of a personality is not the defect itself, but its social consequences"
>
> (ibid. p.36)

Vygotsky stated that children will react emotionally to the same environment in different ways depending on their perception of the experience:

> "in an emotional experience we are always dealing with an indivisible unity of personal characteristics and situational characteristics which are represented in the emotional experience"
>
> (Vygotsky, 1994b, p.342)

A second environmental effect Vygotsky described as a "secondary symptom" (Vygotsky, 1993, p. 255) of differences in natural development is the "underdevelopment of higher mental functions" (ibid.p.255). This is not owing to an inability to develop them, but because the child is isolated from typically attaining children's educational environment. In part because the environment does not have the appropriate means to educate the child according to his/her natural propensity and in part because he may be educated away from his typically developing peers.

> "these condition… impose underdevelopment in the social sides of behaviour as well as underdevelopment in the higher psychological functions, which are formed as social behaviour develops"
>
> (Vygotsky, 1993, p 256)

2.1.5.1 Summary: Emotional Experiences

Emotional behaviour, personality traits and development become secondary victims of the child's individual natural development when it conflicts with socio-cultural norms within an environment built upon the psychophysiological needs of typically developing children. (Vygotsky, 1993)

Thus, with a Vygotskian lens we should explore how the environment affects the child emotionally and developmentally.

We have seen how children's development may naturally vary. The Vygotskian view is that the differences children with SEN bring with them are not the problem; it is the way in which society and its culture responds that has the lasting effect.

One final area of interest to this research from a Vygotskian perspective is that of assessment. Vygotsky was very clear about the importance and kind of assessment that was of value to a child with SEN. I shall now explore this, not as a pedagogical tool but as a socio-cultural tool.

2.1.6 Assessment

Vygotsky stated that we need to understand how the child learns if we are to achieve development for children with SEN. This necessitated assessment of the child. Vygotsky, (1993) made the point that a label of special need and the definition of the label amounted only to a list of symptoms (ibid. p.245). This, he claimed, did not allow of any meaningful understanding of the child to enable better methods of education.

He was interested in discovering the primary cause of a learning difficulty. In this sense he meant that not all symptoms could be the cause of a condition. Some

would be secondary symptoms or consequences of the primary learning difficulty (ibid. p.255-256). Therefore, Vygotsky proposed that assessment of children followed a protocol of actions which would examine not only the child but also the environment and lead to detailed recommendations of support.

He described the kind of assessment he envisaged as "causal-dynamic" (ibid. p.252) in that the whole child within his history and environment was to be considered, in conjunction with symptoms. Facts must be linked dynamically to understand primary and secondary symptoms, the causes of each symptom, which would lead to recommendations for support. One important element is that the child's views must be considered.

Vygotsky stated clear issues to be examined during assessment: the child's developmental history, symptoms, adults' and child's view, upbringing, environment, heredity and educational history, the latter includes the environment at home and school, and the methods of this education. These were all to be analysed in relation to the child's development; not merely listed.

An area that is more contentious is his statement as follows:

> "Psychological diagnostics needs a comparative normative method. The term *normative* here means a kind of psychology which systematically works out objective standards and descriptive formulae for the purpose of comparatively evaluating mental abilities and possibilities"
>
> (ibid. p. 285)

As an SpLD teacher and assessor I understood this statement to mean he approved of normative assessment that would uncover the difficulties in natural development, the primary cause, but also to recognise the strengths of the child which could be harnessed in an individually prescribed education. However, this

stance can be seen as arguing that such children have certain levels of ability in negative degrees to their peers (Gindis and Kozulin, 2007).

I am not able to square the circle in this debate within this thesis. The outcome of assessment, though, I would argue is the most important element and one that Vygotsky made abundantly clear. Recommendations for the child:

> "must be concrete, have content, and offer complete, specific, detailed and clear indications as to the measures to be applied to the child and as to the phenomena or symptoms to be eliminated"
>
> (Vygotsky, 1993, p.291)

To that end Vygotsky recommended that the result of research into SEN should be to uncover educational measures that would be of value to these children, in helping to eliminate secondary symptoms of a natural difficulty and to find roundabout paths and tools to allow the children to develop their higher psychological processes.

2.2 Discussion: Vygotsky's influence on this thesis

As a teacher I have experienced Vygotskian influence on SEN education in England, I recognise his series of assessment protocols in the reports I write as a SpLD assessor and in the use of pedagogical tools and methods to support learning in 1:1 lessons with pupils with SEN.

Vygotsky's theories, to me, suggest a web of related conditions, events and actions that require a holistic response to learners, in particular to those who do not fit easily into the established socio-cultural expectations and conditions of our education system. It is with this in mind that I have analysed my data in order to consider the needs of individuals within a social setting. My over-arching principle being that which Vygotsky stated explicitly:

> "any question of special education is at the same time a question of special education in its entirety"
>
> (Vygotsky, 1993, p. 68)

Its entirety includes the difficulties an individual may face when learning mathematics, the context within which the child is taught, including curriculum and social settings, and the social management by which an individual's needs are understood and met.

I will next be looking at these factors within primary mathematics education. The individuals' needs will be framed within aspects of memory and language and, environmentally, the use of tools, assessment and the curriculum

In the next section I will introduce the background to the mathematics which form the context of this research, exploring how a child's progress can be affected when a difficulty in a particular mathematical skill can be influenced by the child's natural development.

2.3 Mathematics Learning: Introduction

The mathematical development of children and young people is complex. This is especially so when the range of cognitive skills (henceforth described as 'skills') required in becoming numerate is linked to working and thinking like a mathematician, in its basic form showing number sense. It is in number sense that I confine this thesis' investigation as appropriate for the pupils with SEN and MaLD in primary mathematics education, who continue to struggle at this level. These skills include but are not confined to the understanding of symbolism in mathematics communication, the application of memory, the understanding of concepts and procedures and the application of language skills. The list has developed from

extensive reading referred to in this section and includes: Dehaene, 1997, Rouselle and Noël, 2007, Geary, Hoard and Bailey, 2012, Geary, 2004, Riccomini, Smith, Hughes, and Fries, 2015, Siegler, 1988, Tartre, 1990.

In relation to primary mathematics education I will concentrate on the psychological processes of memory and understanding, in the educational approaches to learning concepts and procedures. I will begin by looking briefly at how the literature explains their significance for mathematics in the development of number sense, and explore their relation to difficulties of access for pupils with SEN.

2.3.1 Number Sense

Researchers using a pedagogical framework consider number sense to be an important attribute of mathematical thinking. There is debate as to what constitutes number sense, but I will take Gersten and Chard's (1999) model where:

> "number sense refers to a child's fluidity and flexibility with numbers, a sense of what numbers mean and an ability to perform mental mathematics"
>
> (Gersten and Chard, 1999, pp.19-20)

There are arguments that number sense is an innate ability (Butterworth, 2005). However, Gersten and Chard also point out the environmental factors implicit in developing number sense, for instance the foci of home communications in early childhood. Understanding the nature of any mathematics difficulty I contend is important; however, as an educator in SEN I am here interested in a definition of number sense that will allow us to understand what should be taught, how it can be taught, and what may need to be accessed through special cultural pedagogical tools and methods.

Anghileri (2000) for example encouraged the teaching of number sense ensuring that pupils gained conceptual understanding of number. For instance, when learning the concept of cardinal numbers, Anghileri recommended presenting as many different visual representations as possible. Thus, if I were to represent the number 6 I could show it by its composition as well as its cardinal sense, for instance as 6 triangles, 3 +3 smiley faces and 1 large and 5 small squares (Figure 2.1).

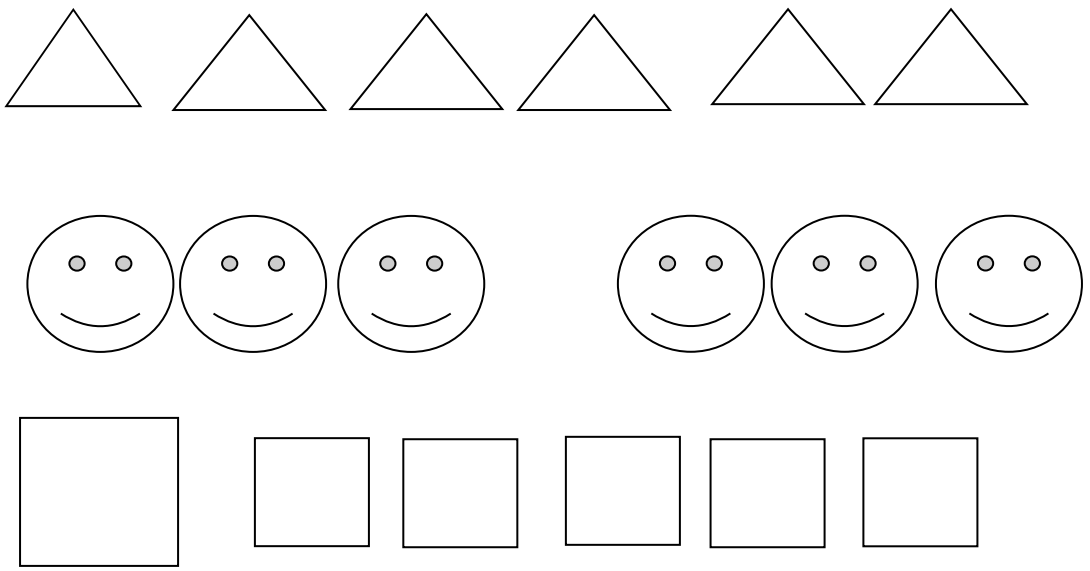


Figure 2.1 My version of Anghileri's (2000) presentation of number

Daniels and Anghileri (1995) explained this as developing a "feel for number" (ibid. p.83) which would enable problem-solving in real life situations.

Number sense, though, may be associated with aspects of what Vygotsky terms natural development as well as with environmental stimulation, given that researchers have found that learners use memory in order to learn mathematical language such as number words (Swanson and Kim, 2007), to be fluid and flexible

with number (de Smedt, Taylor, Archibald, and Ansari, 2010), and to recall number facts and carry out mental mathematics (Geary, 2004).

2.3.2 Memory

The process of remembering continues to be widely researched and researchers argue the importance of memory for mathematics learning (Gathercole, Pickering, Knight and Stegmann, 2004, Geary, 2004, Jonides, Nee, Lustig and Bergman, 2008). The following terms are used in this context: short term memory, long-term memory and working memory (WM). Further information about the definitions I use is found in the glossary. In this thesis I use the terms associated with Baddeley's theory of memory because they have been established within the literature I have used to investigate SEN (Baddeley, 1997).

I consider it important to explain this theory sufficiently here as it has implications for special pedagogical tools, and the use of socio-cultural tools such as assessment, both of which I consider within this thesis. Baddeley's theory, as visualised (Figure 2.2, p.49), describes the central executive as a memory control which places and recalls information into and from two slave systems. The first is the visuo-spatial sketch-pad which memorises and recalls images. The second is the phonological loop which memorises and recalls verbal information. To explain further:

The visuo-spatial sketchpad: this slave system is concerned with information that can be seen and/or visualised in the mind's eye, and/or located in space (Baddeley, 1997). For instance, visualising a room you are no longer standing in, or locating a telephone ringing when you have no recollection of where it is placed. Baddeley

states that this sketch pad uses information both from what is seen and from what can be visually imagined.

The phonological loop: this second slave system requires phonological awareness which is the ability to process the sounds in words (Stackhouse and Wells, 1997), for example by recognising that the words /tin/ and /ten/ sound different, are spoken differently and are spelled differently. People who have weak phonological awareness can have difficulties with reading and spelling (dyslexia/SpLD), but may also have difficulties with storing, retrieving and speaking words, (DLD) (Baddeley, 2003, Snowling and Stackhouse, 2006, Stackhouse and Wells, 1997). The phonological loop describes the process whereby sounds are both stored and retrieved for the acquisition, retention, use of language and reading (Gathercole and Baddeley 1990a and b, Baddeley, 1997).

Baddeley's theory presented a function of long-term memory as a connector of information from different sources. The central executive is vital to this memory system as it co-ordinates the slave systems, and the long-term memory, to retrieve and store information. When information from either or both slave systems, is being processed the memory used is known as working memory**.**

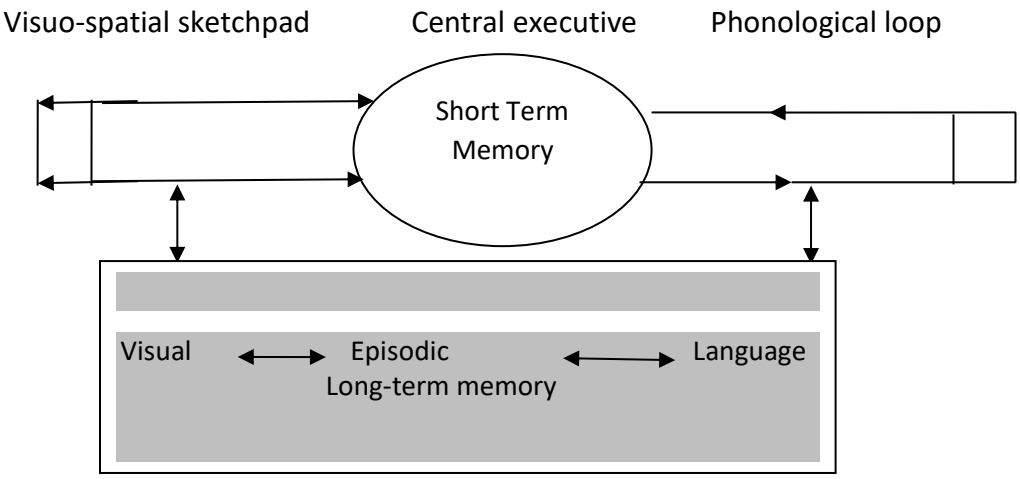


Figure 2.2: Baddeley's theory of working memory, adapted from Anderson (1995) and Baddeley (2003))

2.3.3 Memory: Speed of Processing

There is another influential element of memory, that of speed of processing. Processing is a memory skill that acts upon phonological and visual information; it supports WM in comprehension activities such as understanding the relevant information in a word problem, by enabling the naming of visual symbols such as words and numbers, and by aiding the retrieval of information from long-term memory (Wagner, Torgeson, Rashotte and Pearson, 2013). Children will read numbers and words, respond to problems and questions, and find stored information quickly or slowly depending upon their speed of processing. A mental mathematics calculation, for instance, can be solved at different speeds depending on a pupil's speed of processing, and ability to hold information in short-term memory whilst processing the retrieval of other information, or working on an element of the calculation.

2.3.4 MaLD and Memory

Memory difficulties have been found in some pupils with SEN and MaLD. These difficulties have been established by researchers in a variety of fields, for instance mathematics, phonology and speech and language. This research is ongoing and includes findings related to different functions of memory. All researchers in the discussion which follows have used the Baddeley memory model.

Geary has been a leading figure in memory research within mathematics. Geary, Brown and Samaranayake (1991) found that children with Mathematics Disabilities (MD) did not appear to memorise and/or retrieve mathematics facts to solve addition problems. Instead they chose procedural methods, such as finger counting. He has taken an interest in the function of WM in this context and concluded that children with MD had lower scores in WM.

Geary, Hoard, Byrd-Craven and DeSoto (2004) studied the differences in children's counting knowledge and strategy use in conjunction with their WM capacity. They compared typically developing children (6 – 11 years), with those who had MD. They found, again, that children with MD had comparatively reduced WM capacity, and used less mature counting strategies than their typically developing peers.

In the field of phonology, phonological awareness and phonological memory (Swanson and Kim, 2007, Meyer, Salimpoor, Wu, Geary and Menon, 2010, de Smedt et al, 2010, Van der Weijer-Bergsma, Kroesbergen and Van Luit, 2015) have identified WM difficulties in pupils with MaLD. In addition, phonological awareness and memory has been found to be important for the retrieval of arithmetic facts (Swanson and Kim, 2007, and De Smedt et al., 2010). The importance of the

phonological loop has also been established as necessary in learning language (Gathercole and Baddeley 1990a and b, Baddeley, 1997). This has implications for the learning and application of mathematics language.

Finally, Imbo and Vandierendonck (2007) found that slow processing decreases the pupils' outcomes in fact retrieval as well as their counting and decomposition strategies.

Here there is a possible link between difficulties with the natural development of memory and pupils being seen to have MaLD. I argue that this is important to understand in the context of teaching and supporting pupils with SEN and MaLD, but with caution. Above there are also cultural standards applied within the research methods regarding the forms of memory used and approved, and what are acceptable strategies in mathematics performance.

The above research into memory assumes that number facts and procedures are best performed using either memory of fact retrieval, sophistication in counting strategies, or single digit counting (possibly using fingers). Instead we could consider the possibility that this is a socially constructed belief about being a good mathematician based on the parameters set by the researchers' test conditions and culturally accepted norms.

An alternative view is offered by Gifford (2005) where she described social and cultural factors which could influence a child's mathematical strategies and starting points. She advised observation and interview as additional but important techniques to understand how a child was thinking and responding mathematically, and to establish the reasons for this. Ellemor-Collins and Wright (2007) found

evidence that strategies for addition, differing from the culturally accepted, written procedural form of partitioning and recombining, such as learning to count on and back in tens and ones aided the performance of pupils previously described as low achievers. This is consistent with the Vygotskian view that not all learners respond and perform best to the same methods, leading Healy and Powell (2013) to argue that the kind of mathematics taught, and the experiences of learners, has to be considered in understanding the difficulties they have in the mathematics classroom.

The question of when memory is essential should be considered here. Hewitt (1999) described the difference he perceived between the 'arbitrary and necessary' (ibid. p.4) in mathematics. He described the arbitrary as the names and conventions that we have culturally accepted, and that cannot be derived from knowledge of other facts. These, he argued, require direct teaching and memorisation, for example: a number word, place value layout, how heavy is a kilogram and x before y in co-ordinates.

In contrast, the necessary, Hewitt argued, is found in the mathematical facts, such as number bonds and times tables, which can be derived from mathematical understanding. Thus, he argued, we should teach only the arbitrary facts. The necessary facts will be learned through understanding of mathematical concepts (Hewitt, 2001).

Hewitt, worked on the principle that arbitrary facts must be memorised, and did not consider the role of retention, recall and speed of processing in both securing the "arbitrary" and deriving the "necessary" facts. The "arbitrary" correspond to

Vygotsky's signs, cultural signifiers that we might learn, and which then form part of our higher psychological processes. There is an assumption from Hewitt that all pupils are equally able to memorise these cultural facts. For pupils with memory difficulties this assumption will create problems unless "roundabout paths" to these cultural signs can be developed and used. It can be questioned whether all these arbitrary facts require memorisation.

Ginsburg (1997) pointed out that mathematics teaching in the US was often led by rote-learning of facts and procedures. Rote-learning is defined here as memorisation without reference to conceptual understanding, for instance chanting times tables with no understanding of the patterns, repeated addition or links to division. He compared this to Japanese and Asian methods of teaching which concentrated on understanding of concepts and the solving of problems. He pointed out that the Japanese and Asian students were attaining at a higher level than their US counterparts from very young ages. In the same paper he discussed the lack of motivation, interest and mathematical success in pupils from the US with mathematical difficulties because they were being taught to memorise facts and procedures that Hewitt (1999) would describe as "necessary".

Therefore, I turn to the principle of the understanding of concepts which is the second higher psychological function of interest to this thesis. I will explore concept formation as an important mathematical skill.

2.3.5 Concept

Conceptual understanding I define as an understanding of both the definition and the applications of a concept. Some concepts are learned spontaneously by some

children whereas others will need explicit teaching of the same concept (Anghileri, 2000, Chinn and Ashcroft, 2007, Dehaene, 1997).

If we take the example of the concept of addition, this has been found to have a series of counting strategies which are fundamental as developmental stages (Stock, Desoete and Roeyers, 2009). These strategies include:

- understanding 1:1 correspondence
- a necessary order to number words
- the cardinality principle: the last number word is the amount of the set
- anything can be counted
- order irrelevance: objects can be counted in any order

(Dehaene, 1997)

The concept of addition develops further with strategies and/or procedures to aid counting. Formal addition begins by counting all with fingers (Dehaene, 1997, p.122), where 3 + 4 is calculated by counting on from 1, 2, 3 and then with fingers, for example, counting the next 4 numbers to 7. The commutative principle has been established when addition of digits can be carried out in any order. A further strategy, decomposition, occurs when, for example, 8 + 5 can be decomposed into 8+2=10, 10 + 3 = 13 (ibid. p.123). Dehaene (1997) states that these strategies may appear in any order, that they can be enhanced by explicit teaching, but that many children can and do develop such concepts spontaneously.

This is just one example of conceptual understanding and how its definition and functions are applied to solving problems using strategies or procedures. Some

children do not develop the understanding of such concepts spontaneously. There is a decision here which must be made by educators: whether to teach a memorised procedure or aim to develop understanding of the underpinning concept.

2.3.6 The Memorisation Dilemma

Procedure, the method or methods, by which a mathematics problem can be solved, and number facts can, in theory, be memorised by rote. Research has found that there are distinctions between teachers who use an instructional method of mathematics teaching and those who teach for understanding. Instructional teaching, Lui and Bonner (2016) describe as delivering strategies and procedures to pupils who then practise to consolidate them into automatic memory. An alternative approach they describe as using constructivist methods, teaching to ensure the pupils develop their own understandings based on problem-solving and understanding concepts. Lui and Bonner (2016) found that teachers with little formal background in mathematics were more likely to use the instructional style.

Researchers have argued that teaching mathematics through an instructional procedural model, with rote-learning of procedures, has negative effects on students (Skemp, 1978, Ginsburg 1997) in terms of progress, motivation, self-belief as mathematicians and engagement with the subject. Jackson (2008) found that, out of a group of trainee primary school teachers who self-identified as having mathematics anxiety, a high number had developed the belief that mathematics was concerned with giving correct answers and following procedures. Their experiences of mathematics education had been based upon memorisation rather than understanding.

Skemp (1978) described learning to the test as an instrumental understanding which may be faster to learn in the short term, by instruction, but harder to remember in the longer term because a multiplicity of rules need to be memorised. On the other hand, he reasoned that relational understanding aids the pupil in understanding why methods work. This can be related to Hewitt's positioning of the "necessary", found in number facts, which can also be derived from understanding.

These methods based on understanding have the potential to be adapted to novel problems. Skemp (1971) compared instrumental understanding unfavourably with relational understanding. Relational understanding develops as new mathematical relationships are assimilated into a pupil's schema, citing for instance the use of scales to exemplify equality through addition and subtraction of weights before introducing simple algebraic equations into the same schema.

This type of understanding is akin to Vygotsky's description of developing scientific concepts through explicit teaching and building upon earlier spontaneous and scientific concepts. The conceptual approach has been advocated by a number of researchers (Anghileri, 2001, Skemp, 1978, Chinn and Ashcroft, 2007) and it is the approach that I adhere to. Vygotsky observed that children with SEN did not necessarily learn concepts as quickly or as naturally as their typically attaining peers (Vygotsky, 1998). He therefore argued that children with SEN should be taught concepts explicitly using different socially mediated psychological methods and pedagogical tools (Vygotsky, 1993).

2.3.7 Discussion: Memory and Understanding

Memorisation and understanding are here both recognised as areas of potential difficulty for pupils with SEN and MaLD. In a Vygotskian view neither process is necessarily expected to be acquired as quickly as with typically attaining peers. However, it seems that sometimes memorisation in mathematics is substituted for conceptual understanding when, in fact, both should be viewed as higher psychological processes requiring a mediated pedagogy.

One socially mediated method of access to concepts is the use of speech. Vygotsky described speech as a vital socio-cultural link to the higher psychological processes. Here speech is the act; language is the sign through which speech is enacted.

2.3.8 Language

Vygotsky described language use as an important social and cultural skill:

> "The cognitive and communicative functions of language…become the basis of a new and superior form of activity in children"
>
> (Vygotsky, 1978, pp. 28-29)

This view continues to be held by researchers (Snowling and Stackhouse, 2006, Dockrell and Messer, 1999, Martin and Miller, 2003).

Martin and Miller (2003), like Vygotsky (1997), described vocabulary as labels for concepts. These concepts carry within them increasingly complex information as the child develops. The child will learn, for instance, that words can be related to other words by categorisation, or by being opposite or similar in meaning (ibid. p. 87).

Mathematics vocabulary is developed within a conceptual framework, for instance diameter, radius, circumference and pi are associated with the concept of circles.

The labels must also be linked to the correct technical concept for instance ‘pi’ and ‘pie’ relate to circles in different ways, the former being the ratio of a circle’s circumference to its diameter, the latter a circular chart showing graphical information. Neither, despite the sound, are related to the edible pie associated with food technology and mealtimes except metaphorically and visually in the symbolism of the pie chart.

Monroe and Orme (2010) argue that the ability to progress in mathematics relies on recalling and understanding the vocabulary of mathematics. Pupils must learn the counting words and sequence them for the four operations of addition, subtraction, multiplication and division (Fuson, 1991, Anghileri, 2000). Technical mathematics language presents further challenges: learning the meaning of technical terms such as ‘quadrilateral’ and ‘parallelogram’ and the terms that have different meanings in mathematics from their everyday meaning: ‘table’ or ‘square’ (Monroe and Orme 2002, 2010, Tapson, 2004). Additional complications arise from the abstract nature of some terms such as ‘factor’ and ‘prime’ which have no concrete representations, and the words that are similar in either sound or meaning but have precise differences in definition such as ‘possible and probable’(Tapson, 2004). Finally, words that can be defined differently in various mathematics topics, for example cube as a spatial object and a cube number (Tapson, 2004).

The vocabulary used to describe symbols in mathematics is varied (Austin and Howson, 1979). We use multiple words to define or replace the equals sign: ‘makes’, ‘leaves’, ‘gives’ and ‘is’ (Durkin and Shire, 1991). A study showed that

pupils who do not have a mathematical conception of the = sign as denoting 'the same as', will have difficulties with learning and understanding equations (Knuth, Stephens, McNeil and Alibali, 2006).

Mathematical syntax also requires understanding and application. Mathematics learners can be asked to subtract or take 4 from 10 or respond to ten minus four. Teubul and Nesher (1991) describe how the language in which mathematics problems are presented and the order that numbers are given within a problem can affect the performance of pupils on a task. Okamoto and Case (1996) found that language was also important as "verbal tags" (p.56) in order to apply concepts, for instance which number came "before" or "after" a given number (ibid. p.37.).

Here we can see that mathematics education will require language for conceptual development, and proficiency in semantics and grammar will be necessary. Some pupils with SEN and MaLD have Developmental Language Disorders (DLD) (Bishop, 2014) which can be associated with difficulty in accessing and remembering the vocabulary, concepts and/or syntax.

2.3.9 MaLD and Language

Developmental Language Disorder (DLD) covers a range of difficulties from social communication through understanding of language, expressing language and articulating speech (Bishop, 2014)[4]. It is the understanding of language that will be examined in relation to MaLD. In this context difficulties associated with word learning, the phonological loop, comprehension, and the understanding of concepts have been the subject of research. Dockrell and Messer (1999), Chiat (2000) and

[4] Some researchers use the term Speech and Language Impairment (SLI)

Martin and Miller (2003) have documented the difficulties with learning, retaining and accessing new vocabulary in children with DLD.

Gathercole, Briscoe, Thorn and Tiffany (2008) found a link between phonological short-term memory difficulties, at 5 years old, and the ability to retain and learn new words at the age of 8. They concluded that a group of children with poor phonological memory had impairments in retaining and learning new verbal input. The importance of learning technical mathematics language has been established (Tapson, 2004, Monroe and Orme, 2010, Riccomini et al., 2015) thus difficulties with short-term phonological memory have significance for these pupils.

Language comprehension has been included as a participant measure within some mathematics research. Here various difficulties have been found, for instance a difficulty with story problems in mathematics (Cowan, Donlan, Newton and Lloyd 2005, Krawec, 2014) in children with DLD. Krawec (2014) found that pupils with DLD were significantly less able to identify the relevant information in a word problem.

Pimperton and Nation (2010) explored the mathematical understanding of 7-8-year-old pupils, who had been identified as poor comprehenders. They found that children with poor reading comprehension also had poor expressive vocabulary and lower mathematical reasoning scores than peers with reading comprehension within the average range. They did find, however that the children's ability with mathematical operations was equal to their control peers.

A further area of research with children with DLD is that of understanding concepts. Morin and Franks (2009) described possible difficulties in conceptualisation based on language. They used prepositions as an example of concepts which may be

confusable in mathematics, for example “Put the 6 on top of the 5” does not mean write the number directly on top, so as to hide the 5, and “Put the red block on top of the blue block” has a different spatial conception of ‘on top’ (ibid. p.114). They also cite the use of metaphor as potentially difficult, for instance the number line which shows progression of the counting system but does not convey the magnitude of the numbers, and the use of the terms ‘carrying’ and ‘borrowing’ cited as commonly used by teachers in addition and subtraction operations, which are not physically carried or borrowed as would happen in real life.[5] The metaphorical implications may hold no difficulties for many children but for those who understand language literally, such as those on the Autistic Spectrum (Rundblad and Annaz, 2010) or with DLD, may have fixed understandings of these terms and alternative meanings will require explicit teaching (Whyte et al. 2011).

Thus, children whose SEN includes DLD may present with mathematical difficulties related to the phonological loop and memory, syntactical understanding and/or conceptual understanding.

2.3.9.1 Discussion: Speech and Language

There is plentiful research into the consequences of having DLD on students’ educational progress; there is less on methods of teaching, unless based in visual (VI) and hearing impairment (HI) communities. However, Van Luit and Toll (2015) assessed the efficacy of early intervention for children aged 4 years with DLD, but not VI or HI, using a programme that concentrated on early number skills, including language. The teaching was formally structured using a model which listed the

[5] A more acceptable term is ‘regrouping’ as , for instance, a ten is regrouped as ten units for subtraction purposes, and a sum total of 21 can be regrouped as two tens and one unit in addition.

language to be emphasised, the methods to employ and materials to be used. The children's mathematics attainment reached the level of their typically attaining peers after the intervention, but the longer-term effects were not so strong. Despite concentrating on recommended conceptual approaches during the intervention, the children did not generalise their learned skills to harder mathematical tasks.

A Vygotskian approach would suggest that these short-term, but apparently successful teaching methods could have continued to be employed as "roundabout paths" rather than short interventions. If these children present with DLD, and memory difficulties, within their natural, biological development (Vygotsky, 1993) then continued adjustment of the learning environment would be appropriate.

2.3.10 Summary: Mathematics Learning

Here I have explored two higher psychological functions: memory and understanding, and an important mediating sign in speech and language. Mathematics education currently relies on these functions to be developing in a typical manner. It has been seen above that this is not the case with all children. Memory and language difficulties can impact unfavourably on children's mathematical progress without there being any proof that these difficulties are evidence of inability to learn mathematics (Ginsburg, 1997, Hewitt, 2001, Pimperton and Nation, 2010). Teaching in an instructional, rather than constructivist manner, appears to exacerbate these children's mathematical difficulties (Ginsburg, 1997).

Vygotsky also noted “secondary” symptoms of Special Educational Needs (Vygotsky 1993, p.35). He viewed these as arising from the child’s natural development not matching cultural norms. Without special pedagogies in place for the child to access these norms, the child will suffer further difficulties created by cultural expectations. Here I will look closely at research into the anxiety that some children and adults display when undertaking – or avoiding - mathematics tasks.

2.4 Emotional Experiences: Mathematics Anxiety

Anxiety is defined in the Oxford Dictionary as a “concern about the future” and “excessive uneasiness”. It is an unpleasant feeling that has been explicitly related, for some learners, to mathematics. Mathematics anxiety has been found to affect a range of age groups and cognitive abilities. Gifford and Rockcliffe, investigating the successful teaching practices at Emerson House, where pupils with MaLD and SEN are taught mathematics, observed that:

> “it…seems likely that one of the most important features is a child’s positive self-image as a successful learner of mathematics… This implies the need to monitor the child’s level of stress and confidence”
>
> (Gifford and Rockcliffe, 2012, p.12)

Mathematics anxiety has been explored in relation to its motivating forces, who experiences it, and the behaviours developing from it. I will look at each of these in turn.

For some learners the cause of mathematics anxiety is linked to teaching methods. Skemp (1986) pointed out that rote learning of mathematical rules without resource to conceptual meaning could contribute to the development of mathematics anxiety in learners. Chinn (2008) corroborated this when he found that found that recall of procedures such as long division heightened anxiety, as did

expectations of speed of recall. Some young children (9 – 11 years) had already developed mathematics anxiety, particularly in relation to teaching style, and that the more anxious pupils were those who were taught in a traditional, formal manner relying on the rote recall of facts and procedures (Newstead, 1998). The mathematics anxiety experienced by adults was also found to have started, in some cases, at primary school (Uusimaki and Nason, 2004). Jackson (2008) related these feelings to formal instructional methods of teaching.

Mathematics tests are also a source of anxiety (Chinn, 2008), and test scores are lower in anxious candidates (Maloney, Schaeffer and Beilock, 2013). Adults' ability to perform well in mathematics decreases as time pressures were increased (Hunt and Sandhu, 2017). This study demonstrated that a timed test depressed attainment, but timed conditions with the additional visual reminder of a clock depressed attainment even further. This was especially apparent when the tasks required the use of working memory.

Another factor is pupils' opinions about themselves. Primary age children were investigated in Norway (Skaalvik, 2002) and the UK (Dowker, Bennett and Smith, 2012). Pupils in both countries responded to mathematics in relation to their own opinions about how good they thought themselves to be as mathematicians. Pupils who perceived themselves to be poor mathematicians were more likely to dislike mathematics and to feel anxious about it. Dowker et al. (2012) found that these negative feelings increased with age.

A predisposition to raised anxiety was found, in a review of mathematics anxiety literature, to be more strongly present among children with poor number

processing skills (Maloney et al., 2013). Adults, on the other hand, have been found to have raised anxiety when they present with WM difficulties (Ashcraft and Krause, 2007).

Researchers above have looked at the presence and inception of mathematics anxiety from their various research interests of cognition, pedagogy and attitude. However, whichever viewpoint is taken, a Vygotskian analysis would see the cultural line in all these positions: the pedagogical choices, the pressure of time and speed, the social effect that allows pupils' negative impressions of themselves to develop and the cognitive effects that may not have been supported through "roundabout paths".

The effects of anxiety on behaviour can culminate in various avoidance strategies, diminishing the learners' opportunities to progress, and to engage in mathematics courses and careers (Hembree, 1990). Other behaviours include self-protection, withdrawal, and difficulties with self-regulation and motivation (Rodd, 2006), failing to ask for help, not wanting to engage in new methods, and choosing to make no effort (Turner, Midgley, Meyer, Gheen, Anderman and Kang, 2002).

Avoidance, owing to lack of understanding (Rodd, 2006), was also perhaps a cause of Chinn's (2012) analysis of the use of "no attempt" strategies on mathematics exam papers, which he most commonly found among the lowest attainers. He argued that a fundamental belief about mathematics held by many students is that there can only be a correct answer; failure to find that answer generates feelings of worthlessness. The students' thinking here, he argues, is that it is better to avoid a

task than to attempt and subsequently be found failing which would confirm their lack of ability.

Markku (2006), like Chinn, argued that avoidance strategies reflected the individuals' perceptions of the goals of mathematics. She stated that the individual is encountering a specific environment and has a relationship with it influenced by their personal learning differences. The importance of the environment and pedagogical methods was presented as key to changing attitudes.

Students were less likely to use avoidance strategies in classrooms where there is an "emphasis on learning, understanding and intellectual development" (Turner et al. 2002, p.89). Students confirmed that they did not use avoidance strategies as much when they felt that their "learning, understanding, effort and enjoyment were valued" (ibid. p.102).

2.4.1.1 Summary: Mathematics Anxiety

Mathematics anxiety here has been found to affect learning and behaviour from primary age to adults. There is some evidence that children and students with pre-existing special needs are at increased risk of developing it. Some research has found that negative attitudes persist from early childhood experiences. One of the causes of mathematics anxiety can be found in an emphasis on rote-learned facts, procedures and recall with no underpinning in conceptual understanding or exploration of these concepts. Thus, the mathematics educational environment has a part to play in attitudes towards mathematics. In the next section I examine the social structures in which mathematics teaching in English primary schools takes place.

2.5 Environmental Factors: Mathematics Education

Daniels (2001) argued that the analysis of institutional regulation has a place within post-Vygotskian research. In this context I will refer to the institutional structures that influence the environment in which contemporary pupils learn. One of these structures is the National Curriculum and its objectives; a second is the pace within which the curriculum is enacted. Pupils with SEN and MaLD are expected to be fully included within this environment so I will refer to the access arrangements and strategies that are in place to support their inclusion.

A final element of the environment to which I will refer is cultural, particularly in relation to the needs of identifying and using tools that suit the psychological makeup of individual learners (Vygotsky, 1993).

2.5.1 The National Curriculum

The historical and cultural influence of curriculum content is set within contemporary arguments for inclusion, and expectations of tailored and specific teaching content. In England the National Curriculum (NC) content for mathematics taught at the time of data collection is very clearly described (DfES, 2006).

The key term in recent UK government policy has been 'numeracy'. Historically Cockcroft (1982) described numeracy, and being numerate, as allowing the individual to manage the mathematical demands of everyday life. This included buying, selling and budgeting as well as understanding such things as mathematical information given in graph, chart and table form. He also specified that **"those who set out to make pupils 'numerate'…should not be content merely to develop the skills of computation"** (ibid. p.11, bold Cockcroft's own). Numeracy was thus expected, by Cockcroft, to encompass understanding rather than learning rote

procedures. In 1999 the National Numeracy Strategy (NNS) was launched for primary schools in England and Wales in order to improve standards in pupils' numeracy (DfEE, 1999). It described numeracy as developing competency in number and measure, computation, solving number problems and the practical use of visual data. DfE data showed an improvement in the number of pupils in primary schools reaching an average standard or above in numeracy, in comparison to the strategy's launch date (DfE, 2011). Changes were effected with the Primary National Strategy (DfES, 2006) and numeracy was renamed mathematics.

This latter strategy, detailed in a programme of study (DfES, 2006), was in use at the time of this research. One of its key expectations was that links were to be made between different topics in mathematics and the importance of pupils' understanding was reiterated within the attainment level descriptors.

Memorisation of facts and procedures within the curriculum was also stated explicitly as well as implied within the objectives. The memorisation of facts "recall all addition and subtraction facts for each number to 20" (ibid. p.76) was expected for pupils age 7–8 years. Mathematics facts were further implicitly expected to be memorised for calculation work: "Select and use standard metric units of measure and convert between units using decimals to two places" (ibid. p.83). The language of mathematics was also to be memorised and used correctly 10 -11-year-olds will "use correctly the vocabulary…for lines, angles and shapes" (ibid. p.85).

Memorisation and language have been shown to be difficulties for some pupils with SEN and MaLD. It is therefore interesting to explore how the NC has been made accessible to meet the needs of pupils with SEN and MaLD.

2.5.2 Access for Pupils with SEN

The National Curriculum was written for all pupils educated within mainstream schools in England. Within this context the government took a view that personalised learning would increase attainment standards.

> "to drive up standards whilst also improving social mobility, we are determined to provide more personalised services for children… a tailored education for every child and young person that gives them strength in the basics, stretches their aspirations and builds their life chances. It will create opportunity for every child…"
>
> (DfE, 2005, p.13)

The over-arching goal in the above is to drive up standards. The regulation and checks within which this operates is through a system of data collection by assessment, in primary school KS2 SATS tests, and Ofsted inspections. In brief this system places schools within a market economy whereby parents choose schools based on exam results and external inspections (Ball, 2003). Gove (DfE,2014a) made this explicit in his speech at the Policy exchange:

> "Parents – and governments – must have accurate, fair and timely information about performance, so choice can be informed and state intervention proportionate. The strongest form of accountability comes from the data generated by externally set and marked tests and the judgements made by expert inspectors"
>
> (DfE, 2014a, Gove speech)

The pressure placed on teachers to fulfil the demands of the National Curriculum and attain progress for all pupils, proved by results that meet government standards, has been recorded by researchers (Ball, 2003, Mansell, 2011). These performativity standards can result in teaching to the test and teachers' feeling forced to teach in contradiction to their values (Ginsburg, 1997, Leong and Chick, 2011). Here then the definition of pupil 'needs' appears to have transmogrified into the need to make progress and to prove that progress has been made.

The SATS tests attempt fairness for all pupils by enabling pupils with SEN to access the same exam papers as their peers with some special arrangements - should they meet the criteria for access to these arrangements. The possible access arrangements available are a scribe, reader, modification of the printed paper (e.g. large print, coloured paper), extra time, and "word processors or other technical or electronic aids provided the functionality doesn't give the pupil an unfair advantage" (Standards and Testing Agency, 2018c, p.22). This "unfair advantage" is not defined, its measurement is not explained, and these words assume a cultural acceptance of meaning which is far from clear in this context.

Pupils also have a list of tools that they are all permitted to use in the mathematics exams (Standards and Testing Agency, 2018a, 2018b), a pen or pencil, rubber, ruler marked with centimetres and millimetres, angle measurer or protractor and a mirror. The ruler, angle measurer or protractor may be expected to support some memory work for some pupils, for example the number line, the size of certain angles and the comparative size of centimetres and millimetres.

Whether this is enough to give full access to a mathematics education for pupils with SEN and MaLD, including memory, language and anxiety difficulties, is an area that still requires research.

An extra factor related to the environment and the NC is that of pace, the speed at which the NC is expected to be enacted and the pace at which pupils are required to work within it.

2.5.3 Pace

Time here is explored as a regulating influence on pedagogy and pupil performance. I will look at this first within NC pupil performance requirements, and secondly from the point of view of teachers fulfilling curriculum objectives in the time allotted.

Firstly, in the NC pupils were expected to remember and calculate at speed, for instance pupils age 9-10-years-old will:

> "**Recall quickly** multiplication facts up to 10 × 10 and use them to multiply pairs of multiples of 10 and 100; **derive quickly** corresponding division facts".
>
> (DfES, 2006, bold DfES own p.80)

Speed of recall is then assessed in a mental mathematics test as part of KS2 SATS (Standards & Testing Agency, 2014).

Canobi, Reeve and Pattison (2003) concluded that pupils who understood the commutative principle, would solve an addition problem more speedily than those who did not. Here conceptual understanding is a route to speed of work. However, this differs from fast recall which is placed explicitly in memory. Recalling multiplication facts quickly is a target that potentially places pupils who could be good mathematicians into a different social position because either their speed of processing is slower than the average, or other areas of their memory such as phonological or working memory do not follow typical development.

The pace at which the full NC should be covered is also an area of interest. Teachers, in several countries, have described difficulties with ensuring the full curriculum in mathematics is covered (Black, 2004, Haser, 2010, Leong and Chick, 2011). They all describe the pressure to cover the mathematics objectives as being primed by national tests. Different outcomes have been found owing to this time

pressure. Black (2004) studied the discourse in an English primary classroom and concluded that teachers need "time and flexibility to meet the needs of pupils on an individual basis" (ibid. p.88). Within a time-pressured environment, in this study, the teacher favoured the faster responses of a higher attaining pupil and in so doing emphasised a message that a good mathematician was one who had speedy and faultless recall. This also links with the NC requirement for fast recall (DfES, 2006)

Haser (2010) researched teachers' opinions on the national curriculum in Turkey and concluded that the need to cover all objectives meant that there was an inherent contradiction between the pace of the National Curriculum and the individual needs of pupils; there was no time for teachers to address both simultaneously and successfully. The findings indicated that covering the Turkish mathematics curriculum in inclusive classrooms clashed negatively with the pace that was needed to fulfil it. One teacher interviewed was concerned about allowing pupils to move on to higher grades without understanding concepts

> "When I *[do not teach one concept]* the students pass to the upper grade lacking knowledge"
>
> (ibid. italics my own insertion, p.298)

Keiser and Lambdin (1996) investigated reasons for teachers falling behind in the delivery of the curriculum in the US. Their findings resonated with Haser (2010). The teachers wanted to encourage group learning and understanding. They used tools for this purpose. However, they found that pupils with SEN needed a slower pace both to secure understanding and to manipulate the tools. When the teachers slowed the pace, they could not complete topics by a deadline and then missed some elements of the curriculum.

In Singapore Leong and Chick (2011) noted that to cover the full NC required each component to be taught in an allocated time. Teachers described their goals for teaching mathematics as those of ensuring their pupils understood the concepts, displaying mathematical reasoning and joining in mathematical discussion. However, the reality of time and syllabus coverage resulted in teachers changing their approach to one of direct instruction and memorisation:

> "worthy goals of teaching can be relegated to lower priority because there is no easy way to fit all of the emergent goals into a lesson and yet keep to time"
>
> (Leong and Chick, 2011, p.361)

The literature on teaching for understanding has been covered (pp.54 – 58) however here it is useful to consider the time that may needed to achieve this. Anghileri (2001) and Finesilver (2017) both considered methods of teaching to support understanding of division. Anghileri (2001) looked in general at the outcomes of pupils in Dutch and English primary schools in division problems. She concluded that the time spent allowing pupils to construct their own understanding using strategies built upon their present understanding led to a higher level of attainment for more students in Dutch primary schools, than the pupils in English primary schools who were encouraged to learn an algorithm to calculate an answer. Finesilver (2017) argued that extra time spent with pupils who were low attaining in mathematics would improve their understanding of division problems when they were able to work through the problem in a manner that was meaningful to them, in this case they used illustration at varying degrees of naturalism and abstraction. Both researchers acknowledge the extra time that is needed for this type of learning, but both consider it time well spent.

2.5.3.1 Discussion: The National Curriculum

The NC can be seen to require memorisation and speed of recall within an environment where the outcome of tests is an important factor for teachers' and schools' economic welfare and social standing. Access arrangements for SATS tests are in place for pupils with SEN, however their needs appear to be considered in the light of the need to prove progress rather than their needs as individuals working within a regulated curriculum.

Whether this definition of needs, the available access arrangements, and the current emphasis on performativity is adequate to meet the special educational needs of pupils with SEN and MaLD in mathematics learning is a key focus of this thesis.

I will now look at the mathematics environment in relation to the pedagogical tools that Vygotsky promoted as an alternative route to learning when natural development did not follow a typical path.

2.6 Pedagogical Tools

Pedagogical tools as I define them here are kinetic, visual and technological artefacts which enable pupils to access their education by learning in a style that compliments their natural development. The efficacy of tool use has been shown in research on teaching use of the number-line (Siegler and Booth, 2004) and playing board games to enhance number-line understanding (Ramani and Siegler, 2008).

Neo-Vygotskian research has continued to support the use of special pedagogical tools for pupils with SEN and MaLD. Salomon (1993b) stated that individuals have unique qualities to bring to cognition and these are developed under differing social

circumstances. He argued that tools can be used, firstly, to bypass skills that have not developed naturally. Here, for instance, technology can enable access to the higher psychological processes when natural development has made access to our typical cultural signs more difficult (Choudhury and Crabb, 2015). Thus, for instance, in reading and writing, pupils with SEN may use speech to text software (Dragon Naturally Speaking, 2016) to aid writing, and text to speech for reading (Texthelp, 2015).

In mathematics calculators can now be used to make calculations and will deliver number facts rapidly. Number squares and times table squares give access to number facts whereas tools such as number-lines, Cuisenaire and Numicon give visual representations of number which can aid access to number facts and conceptual understanding (Image 2.1).

Image 2.1 Empty Number-Lines, Cuisenaire Rods, Numicon

Ginsburg argued that memory difficulties could be avoided by teaching for understanding and using tools, in his example a calculator.

> "if (the teacher) attempts to bypass the difficulty by means of focus on understanding…number facts and even allows the use of calculators then the child with memory difficulties is likely to experience no particular difficulty"
> (Ginsberg, 1997,p.31)

Salomon (1993b), secondly, pointed out that tools enhance learning.

> "People appear *to think…* with the help of culturally provided tools and implements"
>
> (ibid. p. xiii, italics Salomon's own)

Here we see their use as an aid to conceptual understanding.

The learning of mathematics language can be supported by tools such as vocabulary lists, placing words into categories with links to their conceptual application. Knuth et al. (2006) exemplify this with the correct understanding of equals as one of balancing both sides of an equation rather than giving the answer. Writing with Symbols, (Widgit, 2000) gives visual symbols to help students to learn and remember words and meanings, as well as understand them conceptually (Pampoulou and Detheridge, 2007).

Mathematics educators and researchers implement and endorse the use of tools in order to teach for understanding (Chinn and Ashcroft 2007, Anghileri 2000, Bird, 2009, Gifford and Rockcliffe 2012). Chinn and Ashcroft (2007) offer wide ranging advice on the use of visual and kinetic tools to support the understanding and recall of mathematics concepts and facts. They give examples such as use of the number line, and the manipulation of Dienes blocks and Cuisenaire rods. They pointed out that resources that were appropriately chosen give the learner "a direct representation of the problem" (ibid. p.133). Emerson House (Gifford and Rockcliffe, 2012) also use visual and kinetic materials for instance dot patterns, board games and Dienes.

Numicon (Elliott, 2008) is a kinetic tool for teaching early number sense, and aiding fact recall, through multi-sensory stimuli: colour, shape and size. This system also describes courses of lessons through which to teach children the skills necessary to

understand basic mathematics concepts. Numicon offers training courses to teachers and support staff wishing to use the materials. Similarly, the advice given by Chinn and Ashcroft (2007) and Elliott (2008) imply a certain level of training and knowledge is important to use resources effectively.

2.6.1.1 Discussion: Pedagogical Tools

Szendrai (1996) cautioned that if resources were not used correctly, they could confuse rather than improve pupils' understanding. It would be impossible to cover all research and all types of mathematics tools within this section; however the use of tools for the right child, at the right time, in the appropriate manner would seem to remain an appropriate Vygotskian approach endorsed by mathematics practitioners and researchers.

The final section of this literature review examines approaches to assessment, a socio-cultural tool. For pupils with SEN and MaLD with severe and specific difficulties, Gifford and Rockcliffe (2012) advocate individual assessment in mathematics for those with severe and specific maths difficulties in order that assessment may inform practice that enables the pupils to access and enjoy their mathematics education. Not all assessment in the environment of mathematics education, however, is used for this purpose.

2.7 Assessment

One form of assessment in England fulfils the government policy of recording pupils' progress at the end of KS1, 2 and 4 in SATS tests and GCSE or equivalent at KS4. Pupils' progress towards these tests are generally recorded by teachers during each school year in order to ensure that they are keeping pupils on track towards fulfilling the NC requirements at the expected test level outcomes. They may use

Assessing Pupil Progress (APP) grids to highlight topics that are secure, almost attained and not attained.

This form of summative assessment gives information about the pupils' ability to carry out tasks in the NC, however it does not inform teachers about how the task is, or is not, achieved (Harlen and James, 1997). On the other hand, normative and psychometric assessments have a scale of scores that have been standardised against a large population. They are regularly used by assessors such as educational psychologists, speech and language therapists and SpLD assessors to place pupils within an ability or attainment level.

There are a range of commercial standardised and summative assessments for maths teachers to analyse where there are topics of difficulty within an assessment of their pupils' current mathematics attainment. These offer, variously, standardised scores, comparison with the mean for different groups of children such as SEN and EAL and lists of areas of difficulty for each pupil. However, again, these tests don't reveal what is making any topic difficult for the pupil, any barriers to learning or how the pupil may be helped

Emerson and Babtie (2010) have produced a book for dyscalculia assessment which looks at, and gives advice on the early, essential stages of maths number sense with resources for teaching. This assessment moves away from a summative attainment score, however it does not cover all difficulties, for instance the language of maths. Emerson and Babtie, however, are moving towards a more dynamic assessment by offering resources for supporting the difficulties recognised through their assessment.

A Vygotskian assessment would also include an understanding of the environment, children's backgrounds and the skills, the children's natural development that they are bringing to their mathematics education. As far as background and environment are concerned an understanding of the child's skills set in the environment can allow consideration of the way in which the environment may be changed to accommodate the children's needs, thus we must understand what these needs are.

It has been demonstrated above that memory, conceptual understanding and language are key skills in mathematics attainment and understanding. Pupils who are low-attainers in mathematics require targeted support that understands these differences, using tools and methods that have been appropriately chosen. Abbott and Lucey (2005), writing about technological tools, warned that misuse of tools is possible if their purposes are not properly understood, or used for pupils who have no need of it.

The assessment of memory and language functions therefore may have relevance to understanding the needs of pupils with SEN and MaLD. In diagnostic assessment qualified assessors accepted by the SpLD Assessment Standards Committee (SASC) include memory assessments within a diagnostic report. These assess relative strengths and weaknesses, for instance in working memory and phonological memory (Wagner et al. 2013) and speed of processing (Smith 1982). Additionally, a speech and language therapist is able to assess a variety of language and speech abilities. The tests in the Clinical Evaluation of Language Fundamentals (CELF-V)

include assessment of vocabulary, understanding and expression of grammar, concepts and directions (Wiig, Semel and Secord, 2013).

Such assessments give standardised scores to elucidate aspects of the natural line of development. Recommendations by the assessors, though, are general rather than domain specific, for instance the assessors are not necessarily mathematics specialists. However, their results are used for applications for access arrangements in examinations, in decisions about making an Education, Health and Care Plan and in decisions at Special Educational Needs and Disability Tribunal (SENDIST).
These assessments may be useful in highlighting the areas of specific difficulty for which pedagogical tools may be useful and what could be developed to target these specific difficulties in future research.

2.7.1.1 Discussion: Assessment

The socio-cultural tool of assessment covers a variety of purposes and types of result. Children with SEN and MaLD may require a mixture of the forms of assessment described above in order to ensure that they are being taught according to their individual requirements in accessing the culture that their typically attaining peers manage much more readily. The most appropriate assessments, from a Vygotskian perspective, will be those that lead to the development and use of special pedagogical tools and methods which will enable the pupils' enculturation, emotional safety, and development of higher psychological functions.

2.8 Summary

This literature review has led me to believe that it is necessary to seek out answers to my three research questions.

1. What are the feelings and beliefs about, and experiences of, mathematics education expressed by pupils with SEN and MaLD, their teachers and Learning Support Assistants?
2. What are the main factors shaping these beliefs, feelings and experiences?
3. What are the roles of tools in disrupting the course of these factors, and contributing to improving outcomes?

From a Vygotskian perspective I have found that the natural line of development can clash with expected cultural development in such a way that the effects can have a disabling effect on a learner who has one or more natural facilities impaired. The literature above has shown that memory and language facilities can be impaired in some pupils with difficulties in mathematics learning.

Vygotsky pointed out that the culture, and product, of mathematics learning is imbued within the mathematics classroom from the start of any child's education. This culture is found in various levels of influence from government directives in the National Curriculum and assessment, to the methods and tools that are employed by the children's key educators. Another influence that is therefore significant to my research is the beliefs, feelings and experiences of these key educators which may have a bearing on their teaching and support. I anticipate that the pupils will also have developed beliefs about the mathematical learning environment and their place within it, and I wish to explore their views.

In addition, research has found that pupils with SEN and MaLD are less likely to do well in mathematics attainment tests. This is a motivation for me to explore any influential factors. The literature showing that low attainment in mathematics can

lead to unpleasant “secondary” symptoms of mathematics anxiety, resulting in avoidant behaviour and further lowered attainment, increases my interest in exploring the feelings, beliefs and experiences of pupils, LSAs and teachers within mathematics education.

Secondly, I am interested in identifying any common factors that the interviewees reveal as influencing their opinions. As an educator, however, it is not enough to find out what is happening and why it is happening. I also want to consider views on special pedagogical methods that may improve outcomes both emotionally and in terms of attainment.

Vygotsky was very clear that the child is socialised by his/her culture. The environment, in the literature has been found to be influential in this regard; an environment always has potentialities for change. If changes are to be made they must be for the right reasons, and for the right effects. These all have to be identified. Vygotsky argued that tools were an important cultural device in improved changes in outcomes for pupils with SEN. This led me to my third question, investigating whether there are any tools that can bring about positive change.

I now move on to my methodology chapter to explain how I gained and examined the information I received from pupils, teachers and LSAs about mathematics in a primary school.

3 METHODOLOGY

3.1 Introduction

I begin by explaining why I used interviews to explore my research questions and who I interviewed. I next describe the procedures I followed to ensure ethical practice. I continue with an evaluation of my use of trustworthiness to support my analysis. A description of the interview structure is followed by a thick description of interview events, and post-interview procedures.

3.2 Interview Research

Interview research expresses an interest in the interviewees' "distinctive meaning or perspective" (Yin, 2014, p122). Interviews are a means to explore the experiences and professed beliefs of the interviewees, and how they understand these experiences (Seidman, 2013).

Seidman (2013) pointed out that interviewees have different lives outside the shared setting but that, within the shared setting, they are "affected by common structural and social forces" (ibid. p.55). Through interviews I explored the experiences of teachers and pupils within maths education. It was not my intention to test a hypothesis but to listen to, record, and analyse the experiences of those teaching and supporting pupils with SEN and MaLD, and of the pupils themselves. The aim has been to describe interviewees' experiences:

> "....in compelling enough detail and in sufficient depth that those who read the study can connect to that experience"
>
> (Siedman, 2013, p.55)

I was not only interested in individual stories and their relation to the wider historical and cultural context, related to mathematics learning, SEN and the curriculum, but also in the interrelationship between these target groups and their cultural context. I have used this position to develop my analysis from a Vygotskian perspective. As such the social, cultural and historical contexts in which the pupils are educated, and the staff have been educated, trained and work in have been assumed to have an impact on their experiences. I viewed this interview research as allowing me to explore a model of social constructivism where I accept that:

> "people actively…seek out, select and construct their own views, worlds and learning, and these processes are rooted in sociocultural contexts and interactions"
>
> (Cohen, Manion and Morrison, 2013, p.23)

In my analysis I discuss the issues expressed and experienced by teachers, LSAs and pupils in a primary school when teaching, supporting or learning maths. I concur with Seidman's views (2013) that the researcher not only maps themes emerging from the experiences of different people within a shared environment, but also presents the themes for readers to "deepen their understanding" of their own experiences of teaching and/or learning maths (Siedman, 2013, p.55).

I have made a deliberate choice of presenting the analysis with a view to supporting change. I regard this as essential to support social justice for pupils with SEN who struggle to make progress in their mathematics learning. Data were provided, p.16, showing that pupils with SEN make less progress in mathematics than their typically developing peers. The literature review describes research into the difficulties that pupils with SEN can encounter when learning mathematics. I argue that, in order to

plan for change, practitioners should take into account the stories of participants in mathematics education, analyse the basis of conflicting and agreeing viewpoints, and understand perceptions of barriers to progress. I am seeking "the improvement of aspects of...social institutions" (Munn-Giddings, 2012, p.72) by analysing how pupils, LSAs and teachers experience and feel about mathematics education within the broader social context of cultural expectations and the microcosm of one school.

I argue that this is an appropriate model for working within a Vygotskian framework as it acknowledges the cultural and social setting within which the interviewees are working, as well as their personal responses to them; thus, assuming the dialectics of the social and the personal.

3.3 Stakeholders' views

I hold with Mertens' beliefs (2007), which support the transformative paradigm, that:

- reality is a social construct
- methods should acknowledge the complex realities of the research topic
- that a link between researcher and participants is necessary to become aware of the cultural setting
- that the ethical values of respect, human rights and social justice must be central to practice.

Vygotsky argued that 'all psychological characteristics of a handicapped child have as their basis a social, not a biological core' (Vygotsky, 1993, p.82.). Interviews give the researcher a means of presenting the views of people affected by social

encounters within a particular cultural milieu. I was interested in gaining information from “multiple realities” through an interview study (Yin, 2014, p.122)

The right to be heard and taken seriously is, in the case of pupils, supported by both United Nations (UN) legislation, article 12 (UN, 1992) and the DfE (2015b). UNICEF (2016) presented data pointing to positive educational experiences when engaging with children’s rights. Lansdown, Tomerson, Sharoozi (2014) argued that adults do not have enough information about children’s viewpoints and experiences when making decisions about and for them. They argue that decisions which are informed by children’s views will have more relevance, effectiveness and sustainability.

It is not only the effect upon the pupils’ education but also the effect upon the lived experiences of the adults that should be heard. Adults also have viewpoints, and cultural demands and expectations made on them, about the education of children in their care, for instance the delivery of the National Curriculum. Ghesquiére,Maes, Vandenberghe (2004) point out that inclusive education necessitates teachers making changes in the classroom, thus teachers’ views will have an important effect upon the education received by children with SEN.

Some aspects of the impact of LSAs on pupils with SEN and their teachers, as well as their own practices and methods of deployment have been reported (Blatchford, Bassett, Brown and Webster, 2009, Webster and Blatchford, 2015). They found that LSAs’ practice was more attuned to work completion than academic questioning and challenge, and there was a lack of training and time for planning with teachers. Owing to these three factors LSAs were found to have a detrimental effect on the academic progress of pupils with SEN in English, Maths and Science at primary

school age, but not of their fault. The authors were not arguing for removing LSAs from the classroom or schools but were pointing out that LSA roles should be subject to enquiry and examination. Thus, I deemed that collecting the views of LSAs' within this research was important.

Through listening to multiple voices in the education of children in the classroom, I am listening to "specific target groups" (Flick, 2014, p.198) who may offer their own special knowledge of the context. This, I argue, is a variation on the "possibility of *multiple realities*" described by Yin (2014, p 122, italics author's own). Yin explained this in terms of interviewing one individual on several occasions, or in triangulating the interviewees' responses with other types of evidence. My approach is to triangulate evidence through multiple stories and viewpoints based within the same setting (Seidman, 2013, Kvale and Brinkmann, 2009).

3.4 The Participants

The interviewees all belonged to the same primary school, a school with a higher than average number of pupils described as having SEN. The DfE (2014b) reported 21.1% of pupils in England as having SEN; the school has an SEN percentage of 29% (Eduexpress, 2015), and a demographic of some deprivation.

In this research I interviewed 19 people from the primary school: six pupils with SEN and MaLD, seven teachers and six LSAs. The pupils were recruited from two year groups, three pupils in Year 6 (10 – 11 year olds) and three from Year 5 (9 – 10 year olds). The pupils comprised of four boys and two girls, one boy in Year 6 was going to move to a school for pupils with MLD for his secondary education, while the other two Year 6 pupils were going to a mainstream local secondary school. The

pupils in Year 5 had not yet chosen their secondary schools. The pupil interviewees were identified by the SENCO who made a list of possible pupil participants. The SENCO chose them through her knowledge of the pupils who were on the school register as having SEN. She also looked at their history of mathematics attainment, for those whose attainment was persistently low and progress persistently slow, who were being supported with one to one tuition (1:1) and small group work outside and inside the classroom. Only one of the pupils, a Year 6 boy, had a statement of special educational needs. The SENCO checked that teaching staff agreed with her identification of suitable pupils.

The LSAs had a wide variety of previous experience. One had changed role from school secretarial staff to support staff 3 years ago, three counted their LSA experience in decades, one had previously begun training as a primary school teacher but had postponed this training, and one was relatively new to the role and had moved from LSA work in the local infants' school.

The teachers also had a wide variety of experience from head of mathematics, SENCO, teacher in training to become head of mathematics, three teachers with decades of experience and one newly qualified teacher.

I knew 5 of the LSAs and 5 of the teachers from my years working at the same school, and two of the pupils in Year 6 who had been at the end of their Year 3 (age 7 – 8 years) when I left the school. The third pupil in Year 6 had joined the school after I left. My insider knowledge of all the teachers and LSAs I had worked with, and interviewed, was that they were hard-working, enthusiastic and dedicated to the school, its ethos and its pupils. They were led by a head teacher who inspired

and respected his staff and pupils and was approachable and respected in turn by his staff, parents and pupils.

Table 3.1 below lists the names of participants used within this thesis. Pupils names start with the letter 'P', LSAs with the letter 'L' and teachers with the letter 'T' for ease of identifying roles. To ensure participant confidentiality, year group, roles in the school and years of work experience are not matched with the pseudonyms and gender has been randomised. Additional steps to preserve confidentiality are described on pp. 90 and 94.

Pupils	**LSAs**	**Teachers**
Paul	Lea	Tess
Patrick	Linda	Theo
Penny	Lisa	Toby
Peter	Liz	Tom
Poppy	Lou	Trudy
Preston	Lydia	Tracy
		Tyra

Table 3-1 List of participants

3.5 Setting up the Interviews

I followed ethical procedures by writing to the gatekeeper (Appendix 1), the head teacher, with copies of all documentation that would be handed out. He gave

permission by email for me to approach the SENCO to arrange meetings and request interviews with the participants.

Following permission, I sent out letters requesting attendance at information meetings for teachers, support staff, parents and pupils (Appendices 2, 3, 4). In relation to the pupils selected for interview, the SENCO telephoned parents/carers to ask for permission for me to approach them, the pupils were not approached directly until I had their parents'/carers' permission to do so. This was to ensure that I followed advice on practice with members of a 'vulnerable population' (Flick, 2014, p.56). Kelly (2007) argued that parents usually make decisions based on what is best for their child.

I held information meetings within the school for teachers and LSAs. No parents requested an information meeting; although 10 parents spoke to me by telephone expressing support for the research. The SENCO had left several sets of staff information sheets and consent forms in the staffroom (Appendices 5, 6).

After parents had gone through the information sheet (Appendix 5) with me by phone I posted them a copy with parent and pupil consent forms, and pupil information sheets (Appendices 7, 8, 9). All possible interviewees, and in the case of pupils, their parents, were given stamped, addressed envelopes to return forms to me, care of the school office. These were not solely for convenience but also to support the confidentiality of respondents

Seven parents returned consent forms giving me permission to approach their children. Once this was gained, I went to the school to meet with the pupils individually and give them information about the interview. All pupils except one

agreed to meet with me. All the pupils knew that I was coming to see them and three knew, or remembered, that I wanted to talk about mathematics with them. I gave each pupil a copy of their information sheet and consent form to take home and discuss with their parents. They did so and each was returned to school signed.

Teachers and LSAs, who did not attend an information meeting, had taken information sheets and consent forms from the staffroom to read and complete at home. Some staff consent forms were returned to me by hand when I was in school meeting with the pupils. Others had already given their consent forms to the SENCO. None of the staff used the stamped, addressed envelopes and this gave an impression of a workforce that was relaxed about being interviewed and being seen to take part.

I then arranged interview dates. The majority of these took place during the summer term 2014, after the KS2 SATS tests had taken place. Two interviews were arranged for one day during the school summer holidays. One was a teacher who volunteered for interview later than the other adults. His interview could not be fitted into the school's schedule at the busy end of term. Another interview was with a LSA who worked part-time, she was not in school for the dates that the SENCO had arranged for the interviews. Both summer holiday interviews took place in the interviewees' houses, by their invitation.

3.6 Ethics

I had gained research ethical approval, number SSHL/13/14-23, from the King's College Research Ethics Committee, before approaching any schools. The pupil interviewees were, at all times, treated as vulnerable participants; they were

children under 16 years old with SEN. I thus applied for ethical approval using the Kings' College, London; high risk RESC/REP Application Form A.

3.6.1 Informed consent

The process of gaining informed consent has been described above. This was carried out to follow the Article 1 of the United Nations (UN). This states that humans are "free and equal" and have "reason and conscience" (UN, 2015), therefore necessitating each participant to give consent to an interview. The Data Protection Act (1998), in use at the time of the interviews, also enshrined individuals' rights regarding their own data. Cohen et al. (2013) pointed out that consent cannot truly be given unless the consent has been informed by understanding of the nature of the research and how it will affect the interviewee. Thus, the informed consent forms contain details of:

- the title of the study
- its purposes
- its possible benefits
- the voluntary nature of participation
- methods of withdrawal
- what will happen if they take part
- the processes followed to maintain confidentiality
- what to do if there was felt to be any harm as a result of the research

In this way I aimed for transparency about my research. There was no need to withhold information for the purposes of research, or of being uncertain of the direction of the semi-structured interviews, as I had an aide-memoire of topics

(Kvale and Brinkmann, 2009, pp.71 – 72) making this a straightforward procedure (Table 3-2, p102).

Informed consent was obtained following a sequence of priorities. Parsons, Abbott, McKnight, Davies (2015) have highlighted the difficulties of finding clear guidelines in institutions of higher education for pupils designated “high risk”. I chose to follow the hierarchy within the school. I had already had permission from the head teacher; I then contacted the SENCO as gatekeeper to the LSAs and possible pupils. Following this I contacted parents as they have legal responsibility to make educational decisions for their children (Family and Parenting Institute). Finally, I contacted school teaching staff, LSAs and pupils. By following a carefully constructed sequence of contacts I ensured that good relations were established with the school and parents (Cohen et al., 2013).

The question of informed consent for pupils with SEN, some with reading difficulties and DLD meant that I changed the format of all documents for them. I used my experience and qualifications as a specialist speech and language teacher, a SpLD teacher and assessor, and an oral language modifier (see glossary) to develop letters and information in short sentences, with simple vocabulary. The information sheet was presented in colour and shapes to signpost meaning, such as differentiating questions from answers (Appendix 7)

I made particularly certain of informed consent from pupils by ensuring that, after my initial meeting with them to explain the research, they took the information sheet home to discuss with their parents before signing. Their

parents had already seen a copy of this information sheet and were prepared for it to be taken home by the child before he/she signed consent.

3.6.2 Confidentiality

Confidentiality was important in order that any report made to the school, or any article published, would not allow the identification of individuals or the school. I ensured confidentiality to reflect the interviewees' right to privacy (Cohen et al., 2013, p.90). By keeping the school anonymous I could be more certain that individuals could not be traced (Seidman, 2013). I did not make the names of interviewees available to anyone else. The head teacher, as gatekeeper, had agreed not to request a list. In practice the staff was very open with each other about taking part in the interviews and was happy to have the interviews in the workplace. Class teachers knew which children were to be interviewed, as they had to be released from class. However, in transcribing and writing up I created pseudonyms for each participant, sometimes also changing gender. This decision was motivated by my desire to maintain the highest degree of confidentiality possible and, since I did not intend to focus on gender as an issue, I felt justified in this latter decision.

I completed the interview transcripts myself, so there was no opportunity for anyone else to recognise voices. I undertook to delete the interviews once transcription had been completed and deleted as promised.

3.6.3 Data Storage

Cohen et al. (2013) advise that data storage must protect against access by parties unauthorized to read the data, from alteration of the data, and loss and destruction

either accidental or deliberate. Thus, I took care in storage of data. This and confidentiality relate to the Data Protection Act (1998), current at time of writing. The information sheets and signed consent forms specified that the data would be anonymised, how it would be stored, what it would be used for, who would have access to the data and for how long it would be kept.

The interviews were recorded on a password-locked Blackberry mobile device. Signed consent forms and hard copies of interview transcripts were kept locked in my desk at home. The transcripts had identities protected by using pseudonyms, electronic versions were kept on a password protected USB: Crypto FIPS 140-2; locked in the desk drawer. The key to pseudonyms was also kept on the USB. I undertook, and am adhering to, the storage of the data for no more than 7 years, and that it will be shared with no one else, unless discussed in anonymised form with colleagues at university.

3.6.4 Participant Comfort

An important concern was the interviewees' awareness that they could withdraw from the research process at any point up to completion of transcription. The Data Protection Act, 1998, was clear that data held and collected should not have a negative impact upon the individual. In the case of interview material, if, for instance, the interviewee was concerned that what they said may impact on them at work, then they should be able to withdraw from the research. I also made it clear that no individual would have to give any reasons for withdrawal, in this way ensuring that no one felt coerced to take part. One pupil did withdraw at an early stage, not wishing to meet with me to talk about the interview. Her choice was, of course, accepted.

Participants were reminded at the beginning of their interviews that they could call a halt to the interview at any time, did not have to respond to any questions that they preferred not to and either choice could be made without giving a reason.

I also wanted to make the interviews as comfortable as possible for the interviewees (Cohen et al., 2013, p.236). I aimed at taking a 'non-judgemental' and 'non-evaluative stance' (ibid. p.435) but also remaining genuinely interested in the views expressed. I tried to avoid direct questions, instead encouraging narrative responses by asking for examples (ibid. p.455).

3.6.4.1 Vulnerable Participants' Comfort

In order to ensure the pupils' comfort, both their initial meeting and subsequent interviews took place in a room they were familiar with. This was a room where SEN support took place and SEN resources were kept. All pupils were offered the supporting presence of a known adult such as LSA or parent, none took up this offer.

3.6.5 Trustworthiness

It is sometimes possible to apply the language of validity to research outcomes (Flick, 2014, Seidman, 2013, Kelly 2007)

> "The strength and soundness of a statement: in the social sciences validity usually means whether a method investigates what it purports to investigate"
>
> (Kvale and Brinkmann, 2009, p. 327)

However, proving validity is more problematic. Multiple conditions within research have been identified as requiring validation, for instance: the analysis of data, the procedures followed by the researcher, the interpretation of the data (Flick, 2014),

and the responses of the interviewees (Kelly, 2007). Finlay and Lyons (2001), for example, described how pupils with learning disabilities might give affirmative answers to any question either to please the interviewer or because they misunderstood the question.

Similarly, a construct of reliability may also be challenged within interview research. However, reliability can be accepted if:

> "…a finding can be replicated at other times and by other researchers using the same method"
>
> (Kvale and Brinkmann, 2009, p. 327)

One area of difficulty in giving a reliable account is through considerations of power. Kvale and Brinkmann (2009) pointed out that acknowledging the truth of any knowledge is dependent upon other people's acceptance of the power of the informant to state that truth, "there is the specific issue of who decides who is a competent and legitimate member of the interpretive community" (ibid. p.256). I argue that this applies not only to the researcher's status as an interpreter of data but also to his/her willingness to accept the interviewees' narrative of their own experiences and beliefs.

In addition to this obstacle to reliability there can be concern about the reliability of the interview material within a structure where power is often, but not always, seen to reside with the interviewer. Arksey and Knight (1999) explain that because the interviewer knows the identity of the interviewee, the latter may be more careful about what they say. The issue of hierarchy and status may also affect the interviews (Seidman, 2013). There can be unspoken tension and anxiety between interviewees and interviewer, when either the interviewer or interviewee considers

themselves of lower status and thus aims to please rather than explore or answer questions fully. Furthermore, an age difference, as well as status difference, may affect the willingness of younger interviewees to give any answers that they do not perceive as the established and expected norm, or a younger interviewee to probe a response more deeply.

Finally, there can be concerns about the reliability of the analysis and interpretation of the data. Scheurich (1995) and Brinkmann and Kvale (2005) argue that the interviewer has dominance through an ability to set the subject and themes of the interview and guide the interview. The researcher then analyses the data in terms of his/her own interests, theoretical framework and what has been termed baggage (Scheurich, 1995, p. 249). Scheurich's term baggage includes considerations of funding, institutional expectations, training in a particular educational discipline and personal idiosyncrasies.

To heed these concerns, I aspire to the qualitative researchers' goal of giving a thick description. The thick description has been described as an ethical stance where the researcher presents and analyses data within a context which is inevitably value laden (Brinkmann and Kvale, 2005, Kvale and Brinkmann, 2009). It supports the trustworthiness of the researchers' data and conclusions, when reliability and validity may be less easy to prove. The thick description, I argue, also corresponds to a Vygotskian approach to the assessment, socialisation and education of children with SEN, for instance: dynamic assessment relies on known facts as well as perceived potential, that social attitudes are judged from Vygotsky's value-laden

position of inclusion and support, and that education can be described from historical, social and cultural contexts as well as the education of the individual.

3.6.6 A Thick Description

Brinkmann and Kvale (2005) described three means by which thick descriptions should be achieved: one is to ensure that context is described, a second is to place the research material within a narrative and finally to focus on particular examples.

3.6.6.1 The Researcher's Position

In this section I explain my own role in the research. The school in which I carried out the interviews was one that I had worked in as SENCO 3 years previously. Five of the teachers and five of the LSAs, had worked with me, and/or had training from me during that time. They knew my background and, I believe, trusted my commitment to SEN teaching.

There were some tensions that needed to be considered as an insider researcher. I had to be certain of the role I was adopting, I had been colleague, manager, and, with some, a friend, for several years. The gap between the interviews and the last time I worked at the school aided my transition to interviewer and, whenever I talked about the research or conducted interviews, I worked hard to maintain this new position, with a neutrality of tone and interest in everyone's views as equally valid (Cohen et al. 2013).

Insider knowledge of what had been in place in the past needed to be expunged from my memory; this was easier with the three years that had elapsed since working at the school. I also had to beware of bias towards one group of interviewees as opposed to others. In practice this was not as problematic as it

could have been because the interviews had a set list of topics to explore, interviewees were encouraged to give full narrative accounts whenever possible and I was not interviewing in order to challenge views but to collect thoughts, opinions and feelings.

Another tension was the adult interviewees' knowledge of my personal commitment, with members of my family identified with SEN, as well as the belief I passed on to them that pupils with SEN can have promising futures, and with the right support will progress. This background has given me an emotional connection to my work and research which I have had to learn to acknowledge when reading literature, evaluating ideas and analysing interviews.

The interviewees' knowledge about me I judge to have had the potential for both advantage and disadvantage. The advantage was a working relationship, and insider knowledge of the institution, that allowed me to start my research at a level of ease and familiarity within the institution (Robson, 2002). Most volunteers for interviews knew me and thus I had a strong chance of gaining interviewees' confidence because they believed I was interested and trustworthy in my approaches. The disadvantage was that some may have professed the views that they assume I espoused, in the belief that this would please me. However in the course of the interviews I did not gain the impression of interviewees saying what they did not believe, although there was a strong corporate message from a lot of the staff that I interpreted as the same team spirit that was present, under the same strong head teacher, during the years I was employed at the school.

Only one pupil recognised me but only in thinking that he had seen me before. This made me a stranger to the pupils which may have made them less certain of themselves when being interviewed. I therefore used the first meeting with each pupil as an opportunity to break the ice (Kelly 2007). I played a 'Getting to Know You' board game that I had devised, in this we played with counters and a dice, moving around a board. At stopping points cards could be picked up with prepared questions attached, including some blank cards for asking your own question. In this way each pupil was able to ask me questions in a more reciprocal relationship. I included informal questions such as where we lived and favourite food and TV programmes to make the meeting more personal and me less of an imposing figure.

My research is self-funded and arose from a drive to improve the progress of pupils with SEN. This position has given me power to develop my research with no obligations to any institutions, and no requirements to report any particular findings. However, I view the research as something that should be shared with colleagues and the wider community through research articles, training and talks. Most importantly my research is centred in the Vygotskian view that disability, whilst still a reality, is also a social construct, that can be challenged and changed.

3.7 The Interviews

This next section covers a "thick description" of the interview techniques covering the format, my methods, events of time and place, adjustments for pupils with SEN.

3.7.1 Format

TEACHERS	LSAs	PUPILS
Past experiences of learning mathematics	Past experiences of learning mathematics	Book look
Current feelings about role	Current feelings about role	Hard /easy interactive board
The current curriculum	The current curriculum	Something learned well/fun to do Something difficult
Good/bad experiences of teaching mathematics	Good/bad experiences of supporting mathematics learning	Experiences of support
Enjoyable aspects of teaching maths Difficult aspects of teaching maths	Enjoyable aspects of supporting Difficult aspects of supporting	Use of tools for learning mathematics
Methods used	Methods used	What makes learning mathematics hard: interactive
Use of tools	Use of tools	Feelings: interactive
Role of teacher and LSA	Roles of teacher and LSA	Three wishes
Relationships between pupil behaviour and progress in mathematics	Relationships between pupil behaviour and progress in mathematics	
Three wishes	Three wishes	

Table 3-2 Aides-memoire for each group of interviewees

I chose to carry out semi-structured interviews with each individual. The semi-structured interview is one in which themes have been decided beforehand but the format and order of the questions can be flexible (Robson, 2002). I created an aide-memoire for the interviews; this was a list of topics that I intended to cover in each interview, although I did not plan to address these in any particular order (Table 3-2).

I had identified topics based on the insights I had gained from my IFS (Bauer, 2013). Several themes emerged from the interviews conducted with the secondary school's participants in the IFS research. One was to do with a low sense of confidence in maths learning which manifested in emotions linked with anxiety. These secondary school pupils described themselves as feeling embarrassed, confused and upset in maths lessons. Only two members of staff in the secondary

school, support staff and teachers, recalled learning mathematics as a positive experience.

In addition, I found many of the adult interviewees in the IFS stated that they were concerned about the following as hindering the progress of the pupils they supported: the demands of the curriculum, the pace of delivery, the level at which the pupils were expected to start from, lack of planning time and minimum use of support tools in lessons and support sessions (largely as a result of lack of training in their use, and few resources within the department). The secondary school pupils expressed similar views about their own learning, the pace of lessons and the topics they were finding too difficult to understand. The lack of tools was particularly important to pupils and LSAs. Just one teacher used them as a regular feature of her lessons but she found that lack of planning time prevented her from creating enough resources, or investigating the few that were available. Other teachers did not use them and several believed that they would belittle the pupils. The importance of understanding learning was a common feature of all interviewees as was the belief that understanding was compromised by the pace of the curriculum.

I was interested to investigate whether the attitudes and opinions expressed by the interviewees in the IFS were also a feature of primary education, for instance were the feelings towards maths expressed by school staff and pupils in the IFS already emerging in primary education or was it a phenomenon of one particular school or of secondary maths education? Was the use, and opinions about the use, of tools expressing a particular feature of this one secondary school department or could these experiences be more generalised?

3.7.2 Conducting the Interviews

With all the adult interviews in this current research, I started by asking the participants to tell me about their own experiences learning mathematics. I did so to allow them to become used to narrating with a story that would be familiar to them.

Throughout all the interviews, I endeavoured not to introduce any of the topics in the aides-memoire as leading questions, and thus pre-empt particular answers. I therefore employed, as much as possible, a principle of following up themes when they were introduced by the adult interviewees. I rarely had to ask a direct question about themes to bring them into the interview except with one teacher and one LSA, who were both nervous interviewees, (see below). Thus, I only invited comments about, for example, the use of tools following the emergence of a related narrative.

This was not the case with the pupils, with whom I adopted an approach, using topic cards that allowed them to choose the order of the interview and some degree of autonomy in what they would like to talk about next (Image 3.1).

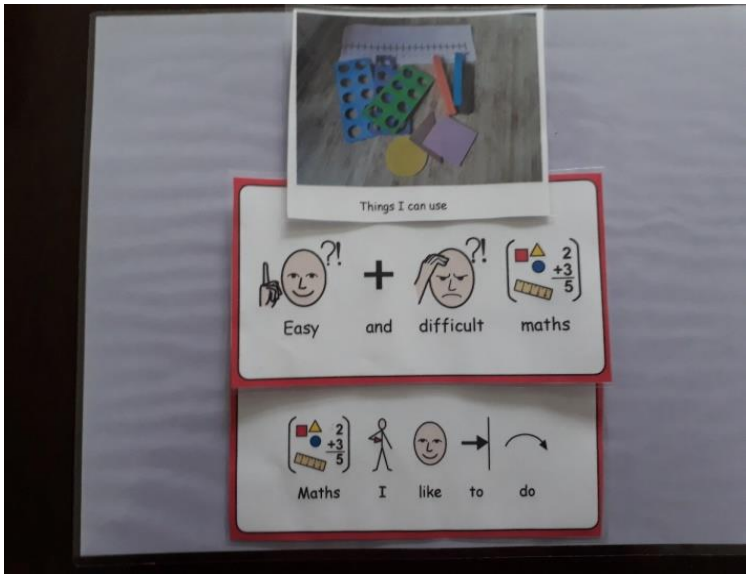


Image 3.1 Examples of topic cards for pupils to choose order of interview

I did not expect the pupils to have the articulacy and analytic skills of the adult interviewees but I did allow them to speak as much as they wanted on anything that they raised or chose.

When following up topics raised by the staff I continued to avoid direct questions as much as possible, for instance when talking about use of tools I did not want to quiz the staff. I deemed this would make the interview feel more like a test. Instead I used requests for narrative “can you give me an example”, “can you tell me about a time when…” after the teacher had spoken in general terms about a topic on my aides-memoire such as a pupil having a lack of recall, or not understanding a concept. Another approach I adopted was to ask for examples of good and bad experiences, enjoyable and difficult aspects of teaching and supporting, or asking how a situation brought to light by the interviewee was managed. These questions were always related to a statement the interviewee had made or a narrative they

had given. This required good listening skills and memory for things they had said some minutes earlier.

The three wishes was a device I used to gauge the relative importance to the interviewees of the issues they had talked about, and also to see if there were points that we had not yet covered but that were important to them. In the event they generally followed the former pattern describing the concerns that were uppermost in their concerns.

I kept each aide-memoire on a book-mark sized piece of paper. It was unobtrusive and enabled me to carry out the interview in a more conversational than formal style picking up on their comments to allow the conversation to move forward, for instance several remarked that they would not like their pupils to learn maths in the same way that they had been taught, this allowed me to ask about changes in practices and their own preferred methods. This often led to a conversation about deployment of LSAs and/or use of tools. Thus, with the adults I tried to keep the interview as open-ended as possible.

At times I did ask some direct questions which moved a theme on, as with "Is there any way round it?" when some teachers spoke about lack of pupil understanding, or 'How do you go about unpicking that?' These direct questions still allowed the adults to use their own narrative and experiences to describe their work. In this way most of the adult interviewees led on to themes that I had listed in the aides-memoire without being prompted. For instance, one teacher expressed enthusiasm about using tools; she introduced this when speaking about maths topics that she found difficult to teach. She reverted to it again when speaking about assessment,

teacher training and data. I suggest that if I had asked her to talk about tools as a discrete subject, she may not have made as many links with the material. This method required good listening skills and an instinct for "steering" the interview if the interviewees digressed (Kvale and Brinkmann, 2009, p.167).

My use of requests for stories allowed me to note strategies, opinions and beliefs that were either idiosyncratic or commonly expressed. Narratives also gave a sense of the interviewees' feelings towards their subject matter; tones of voice and the intensity of expression were useful barometers to aid my understanding.

Two adult interviewees were less forthcoming in their responses, one LSA admitted to nerves at the end of the interview, which underlined to me a sense of the vulnerability that can be felt by participants and the power that is invested in the interviewer, despite my attempts to make the situation as relaxed as possible. This LSA had decades of experience and was dedicated to her support role but finished with, "I probably haven't been very helpful to you". I aimed to reassure her as much as possible; in fact, she had made many interesting points.

One of the teachers was also very careful with her responses, she took great care over her answers, seemed very concerned about being strictly truthful, but also not letting the school down, and this had the effect of shortening some of her answers. Her narratives would unfold but needed a high level of supportive body language, facial expressions and prompts. With these adults, I followed the aide-memoire more strictly and was careful to remain sensitive to the interviewees' verbal and non-verbal responses which suggested, in one case, nerves and in the other

defensiveness (Kvale and Brinkmann, 2009). Thus, there were times when I felt it inappropriate to press for more detailed narratives.

With the pupils I followed their order choice exclusively. Their answers were often shorter, sometimes just one word, and they could not always remember narratives to support their statements. I couldn't be certain whether the lack of memory was related to avoiding the use of language to retell a complicated narrative, or a lot of memories collided making one narrative difficult to pick out, or that they genuinely couldn't remember a single incident. Nevertheless, the pupils provided me with responses, albeit short, that revealed their own perspectives and feelings.

It should be noted that I have not included the interview transcripts in the appendices. I was motivated by strict adherence to confidentiality. The participants comprised a small number of interviewees within a tight-knit community. Should staff choose to read the thesis they may have been able to recognise each participant from such things as narratives, background and identification of their particular roles.

3.7.3 Narrative

The majority of the interviews took place within the school. All the pupils were interviewed in a small room dedicated to SEN resources, one-to-one teaching and SENCO office work. I was alone in the room with each interviewee, but they had been offered the option of another familiar person in the room with them. Each pupil was happy to join me on their own. Three of the LSA staff and five of the teachers were also interviewed in this room. With two LSAs I used a room that was originally a staff room and was in the process of being converted into a larger room

dedicated to teaching programmes to pupils with SEN. The sixth LSA and one teacher were interviewed in their own homes, at their invitation. One teacher invited me to her classroom at the end of school day to hold the interview. The interviews were carried out at a variety of times on three separate visits to the school and two home visits. All the school interviews took place in the afternoons, with cover arranged by the SENCO, for staff coming out of lessons.

Interviews in school, and the two in homes, lasted the same average length of 30 to 40 minutes. The two home-based interviews felt very relaxed and there was an interesting change of dynamic in that I was most definitely the guest and, as such, there was a slightly different power structure. I was still conducting the interview and guiding the structure but the interviewee could guide the use of space and time, for example I was offered coffee, there was time for a chat before the interview took place and I was invited and shown where to sit. This gave time for us both to acclimatise to each other and put researcher and interviewee at ease, it was unusual for me to feel that I didn't have the same amount of control. As both interviewees were ex-colleagues this eased the meetings. In school I didn't sense the same ownership of time and space even when, with one teacher, I was invited into her classroom for the interview. I was not aware of any different types of disclosure or variation of theme as a result of home-based interviews.

Interviews within the office were interrupted on 5 occasions, twice by LSAs needing to retrieve intervention resources and once by a pupil returning resources. This interrupted 2 pupil interviews and one class teacher interview. A third pupil interview was interrupted by a fire bell. This pupil appeared unfazed by the

interruption and was able to pick up fairly quickly after a brief reminder of what we had been talking about. The most frequent interruptions came within the home-based interviews mainly with mobile telephone calls.

Within school, none of the interruptions were expected and each interruption needed to be dealt with without showing any pressure or annoyance. As a guest it was my job to fit in with their needs, and in the homes, it wasn't my place to ask for the mobiles to be switched off, the possibility of a missed emergency under my instigation would have been unacceptable to me. Cohen et al. (2013) point out that researchers create opinions in their interviewees and institutions, and it is advisable to present "themselves as competent, trustworthy and accommodating" (p.82).

During short interruptions I allowed the recorder to continue running, at other times I switched off, for instance during the fire bell. Once I could restart, I reiterated the points we were discussing before the interruption and at each interview this did not appear to change the nature of the interview or the relationship between researcher and interviewee.

3.7.4 Involving the Pupils with SEN

I chose to sit next to, rather than facing, the pupils when I interviewed them. It meant that none of them had to make eye contact with me if they chose not to. It also led to less powerful spatial positioning of me during the interview.

I wanted to ensure that the interviews were accessible to pupils with a variety of SEN. One method I used to achieve this was to make graphic symbol cards, using Writing with Symbols (Widgit, 2000), to support concepts visually, such as maths

words and emotions. Pupils had the opportunity to choose words, or words with symbols for their cards, to suit their preferred reading method.

I also made some simple interactive material, firstly in order to support any language barriers, but also to give opportunities for multi-sensory engagement to aid concentration and focus. I made small topic cards relating to possible situations in the classroom that pupils might want to talk about (Image 3.2)

Image 3.2 Sample of cards related to classroom learning

These topic cards were used with Likert scale cards, with Velcro attached; for the pupils to rate feelings and attitudes that they felt helped or hindered them in the maths classroom and to give a stimulus to conversation and narrative. I found that two pupils tended to choose a mixture of words only and word and symbol cards, most preferred word and symbol (Image 3.3).

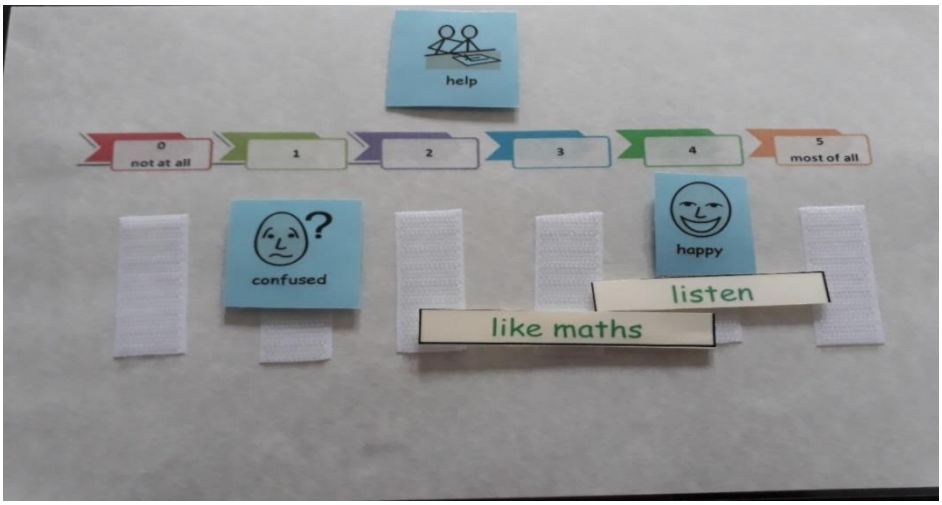


Image 3.3 Pupil card rating feelings during help from LSAs

I also used such cards to place on a hard/easy topic grid to stimulate conversation and narrative (Image 3.4).

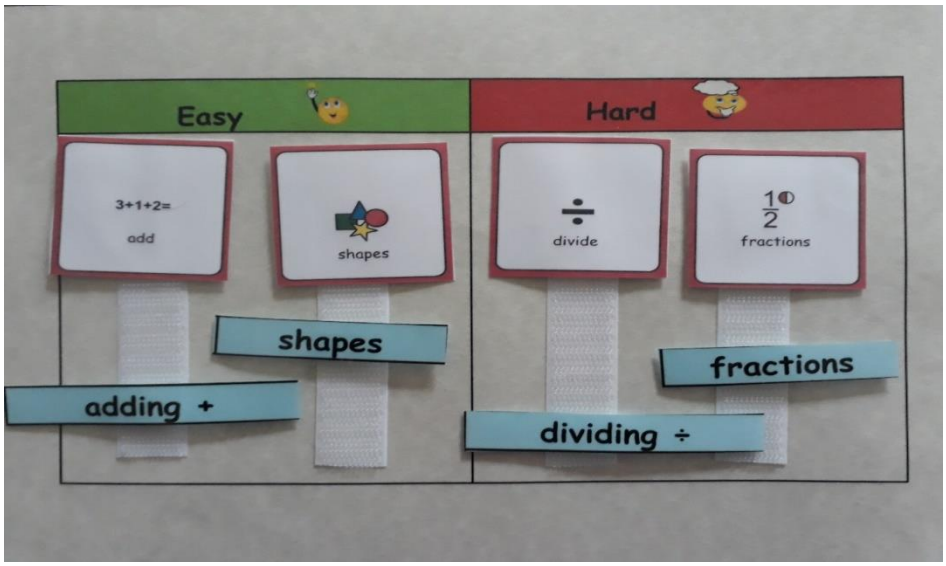


Image 3.4 Samples of cards for mathematics topics

When using the cards during the interviews I found that I used them in a more flexible way then I had initially envisaged. I had placed the cards in envelopes to match with the various interview topics. However, I found that the cards, during each interview, could support further expression of thought, for instance emotions

cards were used again when speaking with one pupil about receiving help (Image 3.3). Here it was useful to see that LSA support gave emotional support as well as, behaviourally in a desire to listen more, and educationally by reducing her feelings of confusion. I implemented this flexible use of cards extensively when, for instance, I was exploring the use of tools. This I viewed as a strength of card use because it had a similar effect to that of picking up on narrative cues with adult interviewees: to introduce new topics and explore them in more depth.

The cards had been created to encourage the pupils to express themselves as much as possible. My impression was that they helped greatly, but I had to be cautious that not everything was taken at face value. Many pupils stated that 'adding' was easy when looking at topics, this was a relative position. They enjoyed demonstrating their ability in this field, but their successes were still limited, it was important that I included narrative and demonstration wherever I could in order to support and explain card choice.

Every choice of vocabulary and symbols on the cards had to be carefully considered. I reasoned that it would be easy to put words into the pupils' mouths. I therefore made cards which, where possible, offered both negative and positive options. With the emotions for instance embarrassed/proud, happy/sad were offered and each one was talked about as they were taken from the envelope. One limitation is that I cannot possibly have considered every possible response. However, by using what I had learned from the literature review, for instance about mathematics difficulties and mathematics anxiety I could at least offer options that had been

articulated or observed by other researchers. Additionally, I used my own experience as a specialist teacher in recalling what pupils had told me in the past.

The layout of the scale cards was also significant. I used a range from binary choice Hard/Easy (Image 3.4), Likert Scales (Image 4.1) and hierarchical scales (Image 5.1). Each presented problems, most pupils for instance were able to recognise that some mathematics topics had aspects that were hard as well as easy and wanted a 'medium' category, we resolved this by making a separate pile for these. The hierarchical scale had 6 options, the pupils understood this well but we used just three or four scale points, partly because I had created cards that were bigger than the option spaces, but also because I judged, during the interviews, making choices then ordering 6 choices was unnecessary and was too much of a burden for most of the pupils. The pupils though understood the layout of 1, 2, 3 in vertical order far better than the Likert scales. The Likert Scales were in fact the hardest for the pupils to understand, I wondered if these had the same effect as number lines, and the question whether number 1 or number 5 was the most important or strongest created confusion for them. This is unsurprising in hindsight when number 1 is associated with being first, they needed a graphic illustration to indicate intensity, they rarely used the central numbers once they had understood what they were to do.

However, I judge the use of cards to be successful in allowing the pupils to explore a range of feelings and thoughts that they may not have been able to verbalise without some vocabulary being available to them. I witnessed their instant recognition of emotions and difficulties they found in the classroom. The difficulties

were not the same for each for each pupil which suggests that the pupils were relating the cards to themselves very carefully. There were moments of trust that developed because I was acknowledging feelings and difficulties before they needed to express them. I suggest that they were able to state exactly how they felt because they were recognising themselves within the cards. They were not being expected to please the interviewer by suggesting that all was fine.

Finally, Bedoin and Scelles (2015) have highlighted the need to allow for digression when interviewing pupils with SEN. I found this to be particularly apposite to my interview with Penny. She was fascinated by my Blackberry for recording and then spoke about the mobile phone she was allowed to have when she went to secondary school. She wanted to talk about her school move; explaining that she had "already got a bodyguard in case I get bullied" and that one of the bullies "punched a teacher in the face and gave him a black eye". I judged that taking an interest in topics that she wanted to tell me about gave me the credibility that I was interested in all her opinions. By using this strategy, I found that pupils would give extra comments without being asked directly

3.7.5 Recording

I made no attempt at hiding the recorder from any of the participants and, before switching on I reminded them all that: the recording could be stopped at any time, that I was using the recorder because I wouldn't be able to write or remember everything that we said and that the recording would be deleted once it had been transcribed.

Most pupils switched on the recording device themselves. I was not aware of anyone who appeared unnerved because of the recording.

3.8 Post-interview Procedures

3.8.1 Transcription

I started the transcription process as soon as I had completed my first set of interviews. I decided to describe tone of voice and pauses, non-verbal utterances such as laughter, as well as verbatim speech. This was not a linguistic analysis, so I omitted detailed timing of pauses, inflection and stresses.

The tones of voice and verbatim speech could support each other in explaining for instance the frustration expressed by Lydia, LSA, talking about the pace of the National Curriculum,

> "*(sounds impatient)* I I I personally I I couldn't be more frustrated when I'm in a maths lesson or lots of maths lessons consecutively and we we're moving on it's it's we're doing expanded methods now we're going to do um oh division"

However, in the coding and analysis, I usually used these descriptions to ensure I had interpreted the transcript correctly, rather than as a discourse analysis tool.

I chose not to use punctuation in the transcription, apart from when denoting pauses. Seidman (2013) pointed out that punctuating is in itself an interpretative act. The run-on nature of the speech, I argue, was more truly representative of many of the interviewees' utterances. They made connections and references to topics on my aide-memoire whilst speaking about different topics. It highlighted the

messiness of eventually packing the data into themes, but I saw it as another reflection of the Vygotskian framework of education in a social context.

3.8.2 Contact Summary

After the transcription of each group of 3 or 4 interviews I made a contact summary sheet for each one. The contact summary sheet, as suggested in Miles and Huberman (1994), "captures thoughtful impressions and reflections" (p. 52). They contained brief summaries of the main points on each page of transcription. I also included a "context protocol" (Flick, 2014, p.402) to describe setting, events and personal thoughts. There was no coding but it was a method that helped me to reread each interview with focus on the description of events and topics covered (Table 3-3, Table 3-4)

CONTACT SUMMARY

Name: Poppy **Role:** Year 5 pupil **Interview length:** 26 minutes

Setting: Office used to store SEN intervention materials. Two desks covered with school property. Used two soft chairs in the room, a hard chair placed between when using visual symbol cue cards, Likert scales etc. Environment cramped, soft chairs made the interview less formal.

Events: One interruption for LSA to retrieve some materials. Poppy returned at end of day to give me 3 wishes and tell me what she enjoyed most about learning maths

Thoughts: Poppy did not initiate any conversation, difficulties with recall, time orientation. Sentences very short and needed visual support to describe and collect thoughts. Gave two descriptions of longer length with aid of narrative cuing, one where there was some annoyance at being misunderstood; another on a fun activity in maths.

PAGE	IMPORTANT POINTS	THOUGHTS
1	'point numbers' means decimal numbers	Language
2	Number line difficult, showed in her book, muddle with directions on number line, likes maths if it's 'fun stuff'	Self-Analysis of difficulties and enjoyment
3	Longer Narrative of fun: sports' day exercise Difficulties of decimals, multiplying and word meaning	Higher level maths concept language Practical/applied maths
4	Describing maths difficulties: reading, mental maths, counting , division, shapes language: 'added numbers like 12 times 1'	Self-analysis of difficulties Language
5	Maths words hard, makes her sad. Feels scared and confused, can't remember things she has been taught. Is happy when she has 'guessed' and is correct	Feelings Lack of self-belief Guessing (?) Does she only 'know' it when she perceives it to be difficult?
6	Longest narrative: asked for help, felt sad. teacher told her she should have been listening, she had been, she just couldn't remember, teacher talk is too fast, she can't understand	Collaboration with teacher undermined Feelings Pace, listening

Table 3-3 Example of pupil contact summary sheet

CONTACT SUMMARY

Name: Tess **Role:** Teacher **Interview length:** 34 minutes

Setting: Office used to store SEN intervention materials. Two desks covered with school property. Used two soft chairs in the room. Environment cramped, soft chairs made the interview less formal.

Events: None, no interruptions

Thoughts: Tess lacking in confidence in self, appeared wary of giving perceived 'wrong' answers and needed support and encouragement to give narrative. At times I judged it wrong to push for more information as I did not want to interviewee to feel uncomfortable.

PAGE	IMPORTANT POINTS	THOUGHTS
1	Instant self-identification as someone with 'very little' training in SEN	Training/knowledge Self-belief/confidence?
2	Sees herself as interested and competent at maths. Draws a distinction between pupils with gaps and those with SEN who can't be moved on so easily	Aware of varying needs
3	Describes a pupil with memory difficulties and lack of number sense, wishes the pupil had had earlier diagnostic assessment	Assessment wanted, why?
4	Wants a single rote method to be learned for pupils with SEN. Exemplified a pupil with SEN who learned such methods and pleasingly "hit an average" in SAT.	Learn for test/ results
5	Enjoys giving pupils quirky methods, visualisations, to remember procedures	Memory hooks, personal approach
6	Initiated the value of concrete resources to support low attainers	Concrete resources for low attainers only?
7	Explained the difficulty with maths language, different ways of saying the same thing as in subtraction	Language of maths
8	Too much pressure to hit targets at particular times, feels this compromises understanding, but points out her grandmother had memorised a lot of number facts and rote procedures without understanding,	Understanding valued, rote also acceptable
9	Collaboration with peers and adults is important, for low achievers to collaborate with younger pupils may give them confidence	Collaboration, peers, adults, confidence
10	Supports flexibility with organising group work groups i.e. changing grouping of the pupils for different maths topics. Trusts LSA to take out pupils to ensure the pupil can do a task, and to tell her who needs help	LSA to teach method, teacher's role to identify what needs to be learned? Assessment roles here?
11	Feels LSA better qualified for SEN than she is, doesn't know specific programmes, never been taught. Some pupils can talk about their difficulties. Differentiates between quick fix and long-term solution latter preferred but lack of time and money	Lack of knowledge of programmes. LSA better qualified for SEN. Quick fix v long term. Time and money problems. Self-confidence?

Table 3-4 Example of teacher contact summary sheet

The contact summary sheets enabled me to refine and rephrase subsequent interviews, for instance the pupil interview in the contact summary above alerted me to the Poppy's ability to describe her own learning experiences and where she perceived the difficulties to be despite her difficulties in verbal communication. I ensured that in subsequent pupil interviews I gave as much opportunity as possible to describe why a topic was *hard* or *easy* for them. From these contact summary sheets, I also gained the impression that the teachers and support assistants valued the use of concrete resources but that the teachers were less certain of how to use them.

At this stage, I listened to the recorded interviews several times while viewing the transcriptions until I was able to read the interview knowing where the hesitations, stresses and laughter were placed. This ensured that I did not interpret literally what was transcribed, for instance teacher interviewee Tom "we're all going to achieve the same thing and there aren't any special needs.....so we won't have any differentiation oh that will be good" was delivered in a heavily sarcastic tone when speaking about recent government innovations.

With some of the contact summary sheets completed and having heard the interviews several times each I was ready to move on to the next phase of research into the data. Thus, I also began to code the interviews. Here my work in interviewing, creating contact summary sheets and coding was carried out in a cyclical process; each activity added awareness to the others.

3.8.3 Open Coding

My aides-memoire predisposed a list of possible codes but I decided to code using a procedure informed by the grounded approach (Glaser and Strauss, 1967) that is, one which did not begin with any prepared list of codes but with the premise that the data would reveal the codes based on Vygotskian theory. I wanted to be as open as possible to new codes. I had coded in my short study for the IFS (Bauer, 2013), within a different workplace, analysing the perceptions of teachers, support staff and pupils on learning and teaching maths for pupils with MaLD. I was concerned that using a list of pre-planned codes might predispose a search for data to support what I had previously found. Arksey and Knight (1999) point out that the researcher's own preconceptions may affect her/his understanding of meaning. Charmaz (2012, p.349) argues that the data collected "will reflect researchers' and research participants' mutual constructions". I accept that the literature review and the questions written for interview already reflect some of these constructions.

Coding was carried out in phases and is described below.

3.8.3.1 Labelling

In my first phase of coding I gave labels to pieces of text, whether the text was a word, phrase, sentence or paragraph. The label described the piece of text without interpreting its meaning (Cohen et al. 2013). However, whilst making the contact summary sheets, I had become aware of some language choices made by the interviewees and these led to some of the initial entries in the list of codes. For example, descriptions of learning 'procedures' and 'processes' denoting rote-learning, and sometimes the use of this term, alerted me to look for instances of

this whilst labelling. I read and reread; at times highlighted sections of interest and began to assign codes to these labels (Table 3-5).

CODE	CODE	CODE
Ability: ABIL	Head Role: HRO	Problem: PROB
Answer: ANS	Hard/Easy: HAREA	Process: PROC
Assess: ASS	Intervention: INT	Progress: PROG
At a loss: ATAL	Language: LANG	Real life: REAL
Basics: BAS	LSA role: LRO	Recall: REC
Behaviour: BEH	Memory: MEM	Rote: ROT
Collaboration: COLL	Method: METH	Secondary school: SEC
Differentiation: DIFF	Mixed Ability: MA	SEN: SEN
Dyscalculia: DYS	Numicon: NUMI	Teacher role: TRO
Environment: ENV	Odd ones out: ODD	Time: TIM
Feelings: FEE	Ofsted: OFS	Tools: TOO
Fix problems: FIX	Own experience: OE	Training: TRA
Fun: FUN	Pace: PAC	Understanding: UND
Guess: GUE	Plug Gap: PLUG	Variety of needs: VAR
Group Work: GROU	Pressure: PRESS	Visual: VIS

Table 3-5 Coding by description

This coding, whilst at the early stages and intended only to be descriptive, led to additional areas of discussion in subsequent interviews. For instance, I was aware of many of the staff speaking of recall with reference to mathematics intervention work. I adjusted later interviews to investigate how recall was addressed. This was done with requests for narrative rather than overt questioning; other information on recall came from teachers and LSAs talking pupil progress.

I next moved on to defining and grouping the codes.

3.8.3.2 Defining and Grouping

Miles and Huberman (1994) advised defining codes to support consistency. As I defined codes, I was able to differentiate different elements of the code and start

developing categories for a generic code. The description of coding that became more apposite as coding continued was:

> "…coding is not a one-off exercise; it requires reading and re-reading, assigning and reassigning codes, placing and replacing codes, refining codes and coded data"
>
> (Cohen et al., 2013, p.560)

Thus, the label TOOLS I defined as visual, kinetic and technological resources that aid the teaching and learning of maths. What had originally been a code TOO for tools was now refined into more differentiated descriptions within a tools category. As this school had Numicon resources in every classroom a majority of the new codes included a Numicon code: NUM, but these could also be differentiated. Thus, I developed codes to refine the category of tools in greater detail (Table 3-6)

CODE	**EXPLANATION OF CODE**
TOO	Visual, kinetic and technological resources that aid the teaching and learning of maths
TOOIND	Independent use of resources
TOOLSA	LSA use of tools
TOONUMASS	Numicon for assessment
TOONUMP+	Numicon pupil observations positive
TOONUMOLP	Numicon and older pupils: upper primary/secondary
TOONUMPRO	Numicon to aid maths processes
TOONUMTCONF	Numicon and teacher confidence
TOONUMTRA	Numicon training
TOONUMUND	Numicon to aid understanding
TOONLI	Use of the number-line
TOOVIS	Resources as a visual aid
TOOOTH	Resources mentioned once: use of fingers/bags of sweets/trundle wheels/counting beads

Table 3-6 Grouping and differentiating the code of Tools

This categorising was useful not only because I could give a more differentiated description to codes, but I could see where foci of thought were emerging, for instance many members of the teaching staff described their feelings of lack of confidence in using the Numicon resources. Additionally, lone voices were also more apparent with one teacher, who had undergone Numicon training; about the uses she had put it to in the classroom.

Similarly, I differentiated time codes into a more detailed category list (Table 3-7).

CODE	DIFFERENTIATED CODE
TIM	Time and pace as a factor in narratives
TIMASS	Time for assessment for meeting curriculum requirements
TIMCOLL	Time for collaboration teachers with teachers
TIMCONC	Time for conceptual learning/learning for understanding
TIMCURR	Time to cover the curriculum
TIMDEV	Time to develop new ideas
TIMDIFF	Time for differentiation
TIMFEE	Time and feelings
TIMINT	Time for interventions
TIMPACCURR	Time and pace of curriculum
TIMPACLESS	Time and pace of lessons
TIMPACPRO	Time and pace of progress
TIMPACREC	Time and pace of recall
TIMPAP	Time for paperwork
TIMPLA	Time for planning
TIMSATS	Time for SATS work

Table 3-7 Grouping and differentiating the code of Time

The interviews regularly had more than one code/category assigned to them, for instance, an excerpt from Liz:

> "you know in class they teach them the rules (METHRULROT/PROCROT) but I have to say even I can't remember the rules (MEMRECPROC) for some of those you know the division rules cos all the associated things that go with it a lot of it probably is if you've got a good sense of recall (RECROT) but for some of the children it's almost an impossibility (RECIMP)you can see them all starting from scratch each time (TIMREC) I suppose some of them they get to grips (REC)with quicker (TIMREC?RECPAC/TIMINT) you two times table your 5s your 10s (RECROT?)"

I had assigned the codes of METH (method of teaching), REC (recall) ROT (rote) TIM (time) and PAC (pace). Memorising procedures and number facts was regularly talked about by pupils and staff; pace and recall are above spoken about in relation to these. Time is also part of this discourse and the codes were beginning to shape into possible themes which were not isolated but spoken of in relation to other possible themes, for instance Recall.

3.8.3.3 Describing with Memos

I continued rereading and coding whilst remaining at a descriptive stage. I allowed thoughts to emerge relating to the codes and began writing memos. Flick, 2014, describes memo writing as an opportunity for the researcher to link and create concepts using the literature review and interviewees' quotes as part of developing a theory from the data. The memos were never long but enabled me to record thoughts as they emerged and add to when I had read or heard any extra data that linked to the memo, for example (Figure 3.1)

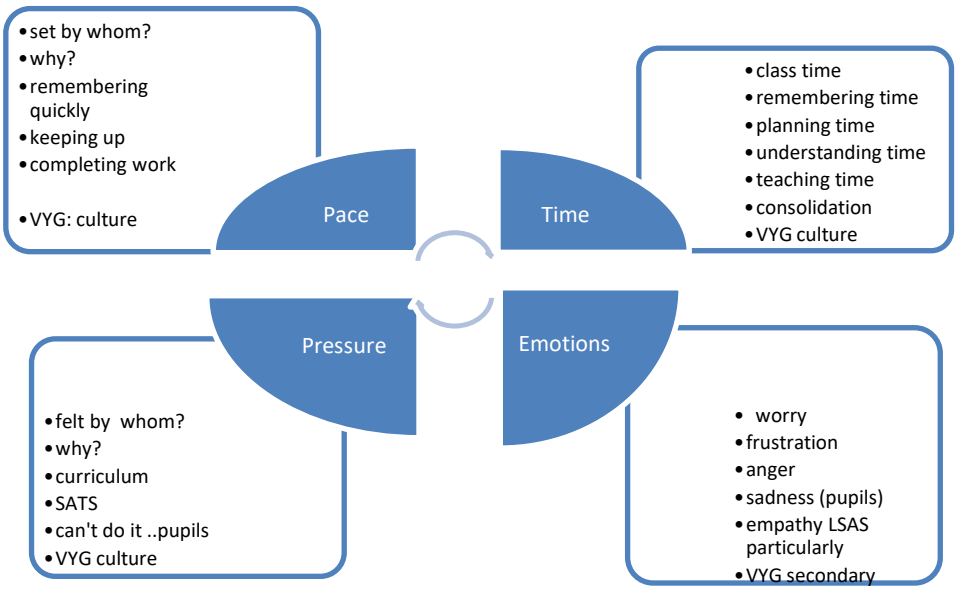


Figure 3.1 Personal memo on time and feelings

3.8.3.4 Code checking

I repeated the coding with unmarked copies of the interviews to compare with my initial open coding but using the newly categorised coding lists. The lists were long but not too large to be able to memorise. In the second coding I found a code I had not initially considered: OBJECTIVES. Objectives had been subsumed into the methods category; however, the meeting of objectives was a topic brought up by

teachers and LSAs and this then made me aware of the remarks made about meeting these objectives, for instance Trudy below:

> "I remember...thinking to myself I'm in year 6 and we've got exams (TIMSAT)(OBJMEET[1]) in however many weeks (PREPROG[1]/OBJTIM[1])…do I just teach these children a process to get them through this test (OBJDAT+[1]/METHALGO)"

I cut the code 'Ofsted' altogether because it was mentioned just once by one teacher. It was in response to my asking how Trudy would **'**evaluate the role of resources in maths teaching'

> "Evaluate it … good question…I mean we do... (laughs)…it's an Ofsted question I should know the answer"

I had not asked that question with the same wording again and Ofsted was not spoken of again. I inferred that it was my choice of vocabulary that had triggered this reaction.

Other initial codes were added into a wider category of code, for instance the term 'basics' was added into the method category, this included memorising the basics of number bonds and times tables and understanding. In this I was applying the 'contexts of interpretation' (Kvale and Brinkmann, 2009, pp.213-214) which they describe in three sections. First is the interviewees' understanding of the term they use, secondly a public or general understanding of the same term and finally what the literature defines when using this term. 'Basics' was a word used frequently by LSAs in the context of knowing number bonds, times tables and the processes of addition, subtraction, multiplication and division. I chose to interpret this as a public

or general definition of mathematical skills. On the other hand, the teachers spoke about processes, concepts and number sense, with only one reference to basics, here the teacher linked this with understanding concepts.

Once I was satisfied that I had read and reread the coding to saturation point, where I was no longer gaining any different insights, or did not find a passage that I wanted to recode, (Flick, 2014) I moved on to deciding themes for the analysis.

3.9 Themes

My decisions on the themes to use to give structure and a narrative to my analysis underwent much revision. I considered the themes I viewed to be Vygotskian in linking the natural and cultural lines of development. I linked for instance pace with memory skills but also with the time constraints of delivering the curriculum, and meeting teaching targets successfully. This method is a version of cognitive mapping whereby I created an 'evolved conceptual framework' (Miles and Huberman, 1994). There was some messiness in the development of themes, and I argue that again this is partly a consequence of a Vygotskian framework which inextricably links the social, historical and cultural. For instance, the LSAs role has a social, interpersonal relation with pupils and teachers, has a historical context within which the role was initially founded and a cultural set of values and expectations which can be described differently by researchers, teachers, pupils and themselves.

To counter the possibility of idiosyncrasy and bias my final decision was to use titles for my themes, which acknowledged a Vygotskian framework, Emotions, Memory, Time. Other codes have been grouped round three main issues: experiences and

beliefs, the impact on mathematics learning and the impact on pedagogy. I have explored these issues in relation to each theme in turn. However, the themes were predominantly determined for the purpose of giving structure and voice to the words of the interviewees. The themes that finally emerged were developed to tell the stories of the interviewees and to demonstrate how they are embedded in the wider social, cultural and historical context of education.

3.9.1 Analysis and interviewees

It should be noted that the analysis does not link pupils with specific teachers or LSAs unless a particularly noteworthy comment was made (see Table 4-15, Table 5-22, Lydia p. 144). This decision was made for two reasons. Firstly, the LSAs were not assigned to the same teacher all the time and they also often shared support of a pupil. One LSA, for instance, may work in the classroom and another on interventions outside the classroom. Secondly, I was not interested in carrying out case studies where the influence of one or two adults' decisions about, and actions to support, a pupil could have significant consequences. Instead I was interested in characterising the beliefs and feelings of different groups thus I have concentrated on the beliefs and feelings that predominate within the structure of primary mathematics education in one school, when following a curriculum and meeting government expectations.

4 EMOTIONS and MATHEMATICS

4.1 Introduction

In this chapter I explore the feelings expressed by pupils, LSAs and teachers. I describe their feelings about learning, teaching and supporting mathematics, and the resultant behaviours that have been observed and/or experienced. I also look at the use of tools and the interviewees' emotional responses to them.

4.2 Learning Mathematics

4.2.1 Pupils' Feelings

The feelings charts completed by the pupils below tell a unanimous story of lack of pleasure in mathematics (Image 4.1)

When the pupils came to choose the cards, despite an equal number of positive and negative feelings offered on the emotion cards, there was not a single immediate positive response.

Four of the pupils explained these emotions spontaneously during the interviews, others as they looked through the emotions cards, and sometimes when talking in general about mathematics and mathematics topics (Table 4-1). The cards they picked showed a range of feelings, but I noted that every pupil chose 'confused'. In addition, out of six pupils, four were scared, three bored, two angry, two felt like crying or cried, two were sad and one embarrassed. This is an alarming range of feelings in children so young.

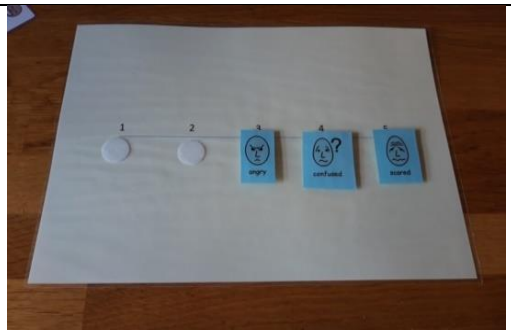
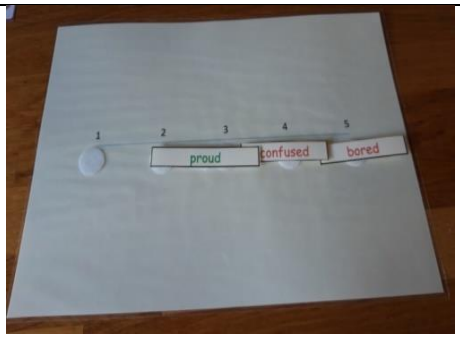
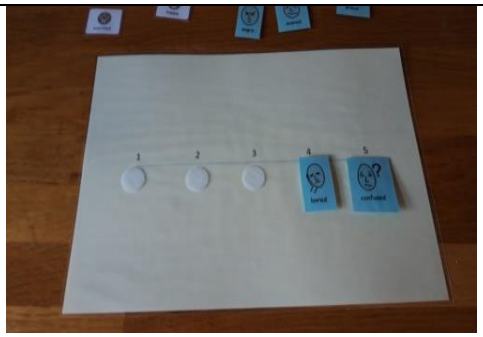
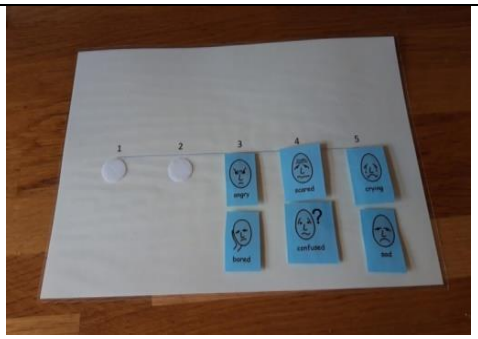
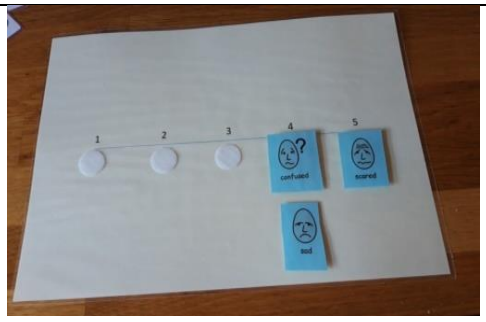
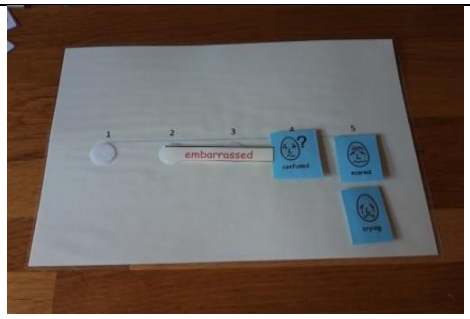
Learning Mathematics: Pupils' Feelings	
PAUL	**PATRICK**
	
PENNY	**PETER**
	
POPPY	**PRESTON**
	

Image 4.1 Pupils' feelings: learning mathematics

Pupils' feelings explained	
Penny	"not really liking it cos it gets too tricky" *She feels bored and confused,* "nearly all the time in maths"
Patrick	"teachers talk and talk about maths and I just oh boring" "adding that's my favourite but I don't like maths"
Preston	"I find it a bit harder then I get a bit worried" *and wanting to cry,* "when it's really difficult"
Poppy	"confused I don't know what to do and sad"

Table 4-1 Pupils' explain feelings

I asked each of the pupils about any positive experiences they had had; two pupils responded to this. Paul was able to relate a standout incident for him: he had recognised that the teacher had made a mistake in her time telling:

> "the teacher weren't looking at it…she put 12 o'clock and it was actually 5 past 12 it was on the one…*how did it make you feel…*happy*"*

Patrick was the only one who then decided to add a positive feeling to the board with "proud" when he spoke of his memory book and the use he made of it. The other pupils did not choose anything from the positive options, even after my prompting.

Penny, in particular, was adamant that none of the positive feelings applied to her when I pointed out the cards:

> "Well I don't really have any of these…don't really have any of them"

4.2.2 LSAs' Feelings

The LSAs' feelings about learning mathematics, were also predominantly negative, five of the six held such views (Table 4-2)

LSAs' feelings: learning mathematics	
Lydia	"at school it was my worst subject"
Lea	"why did you choose maths I hate maths"
Linda	"there was nothing worse than being told you're in the bottom set you know it's a horrible feeling and to go home and have to say to your mum and dad …"
Lou	"there's something you found hard at school… I always come out in a cold sweat"

Table 4-2 LSAs' feelings: learning mathematics

Most of the LSAs' dislike stemmed from their own experiences of school mathematics.

4.2.3 Teachers' feelings

In contrast to the LSAs there was a high degree of positivity among teachers in their feelings about learning mathematics, five of the seven had positive feelings to relate (Table 4-3).

Teachers' positive feelings	
Tyra	"always enjoyed it from my school life"
Tracy	"I did till A level…I feel more confident in my ability my knowledge of maths"
Toby	"I have got a maths background…I understand maths quite well"
Tess	"I do have a genuine interest in maths I'm a reasonable mathematician myself"
Theo	"I love mathematics I'm a maths geek I did A level maths and…at university"

Table 4-3 Teachers' positive feelings: learning mathematics

Two teachers, Trudy and Tom, spoke about their mathematics learning in a less positive light although this was situated firmly in the past tense (Table 4-4)

Teachers' negative feelings	
Tom	"struggled with maths at school" *and* "didn't understand any of what I was actually doing"
Trudy	"didn't like it at school"

Table 4-4 Teachers' negative feelings: learning mathematics

4.3 Supporting Mathematics

4.3.1 LSAs' feelings

In contrast there was more enjoyment in the LSAs' feelings about supporting mathematics (Table 4-5).

LSAs' feelings about supporting mathematics	
Lydia	"now I love it…I feel that I can tell the children you know in lessons and out of the classroom as well I enjoy it…I was…more nervous about it than I am now"
Lou	"I've heard from the teachers it's helping and I'm pleased about that"
Liz	"as far as I'm concerned I would far rather do maths support than literacy support "

Table 4-5 LSAs' feelings: supporting mathematics

4.3.1.1 LSAs' Observations

The LSAs also commented on the pupils' feelings (Table 4-6).

LSAs' observations on pupils' feelings	
Lea	"the ones who just look with big eyes and think please please show me again show me again and show me again"
Linda	"there's some that almost instantly sit up and smile…you see some children go oh (*sad vocal tone here)* …so you can see which ones are keen are which ones are not so keen"
Lou	"if it's something they're confident in they tend to behave better…I think a lot of the children are a lot more afraid of maths than they are of other subjects"
Liz	"what do you do when you've got a child…who thinks that maths is absolutely terrifying"
Lisa	"we do try but it's quite hard and the children don't take to it as easy"

Table 4-6 LSAs' observations: pupils' feelings

Their identification of the pupils' fear may stem from their own experiences and dislike of mathematics. However, they gain pleasure from seeing success in their pupils.

4.4 Teaching Mathematics

4.4.1 Teachers' feelings

Several spoke about their enjoyment of teaching mathematics, including Trudy who had now changed her mind about the subject (Table 4-7).

Teachers' feelings about teaching mathematics	
Tyra	"it's something that I like teaching more than others"
Tracy	"I do enjoy really enjoy teaching maths
Trudy	"It's my favourite subject to teach in the classroom"
Toby	"I actually love teaching maths I really enjoy teaching maths"
Theo	"I love teaching it"

Table 4-7 Teachers' feelings: teaching mathematics

4.4.1.1 Teachers' Observations

There was empathy among teachers for the feelings of their pupils when they perceived they were finding mathematics difficult (Table 4-8).

Teachers' observations on pupils' feelings	
Toby	"I struggle with seeing the panic in their eyes"
Tracy	"they definitely bring in that self-esteem of I'm not very good at maths…so already have a negative idea in their head which is sad"
Theo	"get rid of the SATS tests…it's the pressure of it they go under they act sort of worried…it's not always a true reflection of what they can do"
Tom	"are they always going to be trailing along in the wake of the others and never really getting there and then you've got the psychological impacts of that"

Table 4-8 Teachers' observations of pupils' feelings

4.4.1.2 Discussion

None of the pupils expressed positive feelings about learning mathematics with all saying they felt confused, a majority said they were scared, some bored, angry, sad, and/or crying. Two pupils, Penny and Patrick, had expressed negative feelings before I had even begun to ask about their feelings. My efforts to find some positive responses were not successful with just one pupil finding a single reason to be proud and another an instance of happiness when he realized his teacher had made a mistake. The teachers and LSAs expressed empathetic awareness of the pupils' negative feelings towards mathematics.

Most LSAs, 5 out of 6, recalled mathematics at school as unpleasant with Lea, Linda and Lou recalling painful memories. For Lea her feelings towards mathematics have developed into a lifelong antipathy.

The teachers, by contrast, were enthusiastic about their learning experiences, with two notable exceptions. The majority had enjoyed the subject and linked this with their success in it. Here it was apparent that the teachers who had found success in the subject were much more positive about mathematics than the LSAs and pupils who presented as having had more difficulty with it at school.

Dowker et al. (2012) used a questionnaire to explore primary school pupil's attitudes to mathematics. They found a correlation between self-rating as poor performers and not liking mathematics. On the surface this may reflect the difference in attitudes between the teachers on the one hand, and pupils and LSAs on the other. However, in my data all the pupils expressed confusion, not feeling that they understand the subject, which is reflected variously in negative emotions.

Confusion at mathematics is not the same as viewing oneself as a poor performer. Lea, Lou, Trudy and Tom also described this feeling from their memories of school mathematics. Confusion in mathematics may result in poor performance, but not necessarily, as Tom and Trudy demonstrate. This finding broadens the research into pupils' negative feelings towards mathematics learning and where it stems from, and the relationship between learners' views of the subject and themselves.

My next focus will be on the behavioural effects enacted that result from the feelings described above.

4.5 Behavioural Effects

4.5.1 Anxiety

Four pupils described their emotional reactions to learning mathematics (Table 4-9).

Pupils' anxieties about mathematics	
Preston	"I don't feel as confident as in all the other lessons I don't get as worried there"
First responses to a question about the use of things to hold and use when learning maths	"I just hold things like a ruler or something and I just squeeze it to stop the worry getting there"
On not wanting to ask peers for help	"Like sometimes my friend it's embarrassing cos they know that's wrong and it's unless it's someone I really like and I know they won't say anything it's a bit embarrassing"
On handing in work that he knows is wrong	"I feel a bit worried that they might come and talk to me and I'd get into trouble about it"
Poppy	"everyone else knows what to do and I don't I feel like confused and don't know what to do"
On tests	"scared cos I don't know some of the addings and I didn't want to read in tests and I couldn't really read it"
Paul On tests	"we had to do a test and I didn't think I'd do it"
Peter on asking for help	"I'm not brave enough"

Table 4-9 Pupils' anxieties: mathematics

Preston's lack of confidence displayed as anxiety in his tone of voice and in the worries that seemed ever present in mathematics lessons. He had a feeling that wrong work was bad work with which he could be in trouble.

Peter, Poppy and Preston's responses imply isolation, a non-inclusive state, within a crowd. Peter is too nervous to ask for help. Poppy has the impression that she is the only one in the class who is confused, and Preston is anxious about incurring the negative opinions of peers and his teacher.

Paul told me about his feelings towards tests when he chose the scared and confused card. Encouragingly, these feelings did improve, he said, when he had some help from Lisa in reading and writing.

Here the pupils' feelings display anxiety towards tests, isolation within the class and towards getting help. The pupils are clearly able to articulate the situations that make them anxious.

One teacher, Toby, noted anxiety among his pupils and how it showed in their reactions:

> "you just mention the word maths and they go *(sharp intake of breath)* they start to do it and the fear creeps into their eyes and the confidence just goes"

Two LSAs also expressed anxieties of their own (Table 4-10).

LSAs' anxieties about mathematics	
Lou On forgetting a multiplication procedure	"I always come out in a cold sweat when I'm told we're doing decimals or fractions and shapes…I loathe the shapes" " in the end I had to say to the children even adults make mistakes and Mrs … is very old and very hot and she's got confused…I feel embarrassed if I make a mistake in front of the children"

Lea	"I panic on numbers I don't know…I feel the wall going up I really do"

Table 4-10 LSAs' anxieties: mathematics

4.5.2 Avoidance

Paul was the only student who specifically mentioned avoidance, his anger leading him to go out of the classroom:

> "it make me angry…we're having to take away and I couldn't do it just got angry…asked for time out"

However, LSAs and teachers recognized avoidance as a behavioural reaction to mathematics learning. A few related this to their own behaviours (Table 4-11):

Teachers and LSAs on their avoidance strategies	
Trudy	"I used to blow my nose every time the teacher asked a question cos I think they're never going to pick the child that's blowing their nose…I used to think please don't ask me"
Linda	"if you don't like the subject like shapes if I can avoid it I will try not to go near it because I'm frightened of it and I worry"
Lea	"the higher groups I just sit and watch them I go yes that's right *(laughs)* "obviously addition and subtraction these are ones I enjoy…I suppose it's what we call arithmetic…then you've got c equals y equals forget it I don't know"
Lisa	"I've never worked in years 5 and 6…when I look at the work I don't understand some of the things"

Table 4-11 Staff avoidance strategies

Lea did not explicitly say she avoided algebra but had accepted that she would never be able to learn it. This in turn had consequences as she, like Lisa, preferred to remain working with the younger age groups (Table 4.11). These feelings have limited their opportunities to experience new teaching methods and find out if they could learn. This I interpret as another form of avoidance.

Both LSAs and teachers observed a variety of avoidance behaviours in their pupils (Table 4-12).

Staff observations on pupils' avoidance	
Lou	"they'll just refuse to engage with the activity and they'll start playing up wandering around the classroom or kicking the child next to them or…shouting out…or having a slight tantrum I've seen all of those things" *and* "quietly just not doing anything…hoping that the LSA or teacher doesn't quite get round to seeing that"
Linda	"lower ability children are…a bit anxious or worried about asking another child"
Liz	"don't want to work out…won't put a pencil on the paper…or break it *(the problem)* down into bits"
Toby	"it could manifest in poor behaviour they think actually I'd rather look like I'm being the clown of the class than I can't do maths" *or* "retreat into a shell…just let me sit here and hide for an hour" *and* "children who have struggled before and they've had help and then they think they always get help so there's not always that attention to what's going on"
Trudy	"if any child doesn't really understand they're more likely to misbehave" *or* "be switched off"
Tyra	"when they don't understand it they get frustrated really quickly and then think I can't do that"

Table 4-12 Staff observations: pupils' avoidance

4.5.2.1 Discussion

There are two points I will raise from these data. First, I will look at the ways anxiety and avoidance are expressed by the pupils and then the implications for long-term mathematics education.

The pupils are conscious of their own learning relationship with mathematics and some describe their feelings of isolation. Vygotsky (1993) made a link between emotional affect and learning when he pointed out that pupils who felt excluded by their ability to learn in the same way as their typically attaining peers became excluded from the group (Vygotsky, 1993). Vygotsky argued that this exclusion led to a lessening of their social abilities. There is evidence here of such weakening of social abilities, for example, in Peter's inability to ask for help and Preston's fear of his peers and teacher's reactions. Paul's anger at work he could not manage independently suggests, by his needing to go out, that his reaction is socially unacceptable, and he is somehow at fault.

The implications are found within the inception of mathematics anxiety and its longevity. In this data, anxiety about mathematics was more common in LSAs and pupils than teachers, although Trudy recalled her avoidance strategy when she was at school, incidentally another self-isolating tactic. There is evidence of some LSAs' continuing efforts to avoid what they consider to be challenging mathematics (Table 4-11).

Interviews with student teachers have shown their anxieties about learning and teaching mathematics (Uusimaki and Nason, 2004, Jackson, 2008). Within that

group of student-teachers the inception of mathematics anxiety could be found in primary school education Uusamaki and Nason(2004). The LSAs' comments here support prior research findings that the impact of lack of enjoyment of mathematics at school can continue into adulthood. Importantly the pupils' views here add weight to these research findings but also give us additional reason to find pedagogical methods that will prevent these feelings developing.

I will now look at the implications of this on pedagogical practices.

4.6 Implications for Pedagogy

Vygotsky identified tools as objects that aid our psychological development (1978). He argued that with their use pupils with SEN would access the learning that was more easily available to peers who learned in the culturally accepted manner. Here I will explore the use of tools solely from the interviewees' emotional responses to them: the ways in which they directly support aspects of learning will be addressed in subsequent chapters. Tools will be viewed in their broader sense of tools for pupils' mathematics learning, the cultural tools pupils use for their learning, and society's cultural tools in the form of assessment and the curriculum.

4.6.1 Tools in the Classroom

Patrick was the only pupil to refer to a tool as having a direct impact on his feelings. He had a memory book and he was the only pupil who chose a positive feeling for his emotions cards; when he did so he was referring to his memory book and the pride he felt with it.

> "I've got this memory book now and I just write the important stuff what they say now write it down and then I just open the book and I say oh ok yeah"

I asked him how it made him feel and he chose the proud card and said:

> "like that proud like I'm sort of like yeah I'm better and happy like that was hard and now it's easy"

When the LSAs spoke about tools they were usually referring to Numicon. They all had positive feelings towards using it, expressed strongly. Liz used different tools more often and still expressed her enjoyment with their use (Table 4-13).

Tools: LSAs' feelings	
Liz	"I love using Numicon it's an absolute revelation"
Linda	"I really like it"
Lou	"it's really satisfying it's lovely working with them with Numicon"
Lisa	"I enjoy doing Numicon"
Lea	"I would just say the Numicon is just unbelievable it's brilliant"
Liz	"we've used the times tables keys that's always fun"

Table 4-13 LSAs' feelings about tool use

In addition, Lea and Lisa took pleasure in the pupils' success using these tools; this boosted their own sense of well-being (Table 4-14).

Tools: LSAs' Responses to Pupils' Success	
Lisa	"oh it makes you feel good"
Lea	"I always feel good when they succeed…it's little steps all these little steps…and they would transfer that back into class"

Table 4-14 LSAs' pleasure: pupils' success with tools

Well-being was also commented on by the LSAs in relation to the pupils: (Table 4-15).

Tools: LSAs' observations on pupils' well-being	
Linda	"children get a bit more confident" "the children feel safe"
Liz on Paul card games	"it is so nice for him to be able to do it…on his own and I think they don't have to keep asking you have I done it right…it's great" "it's nice for them to say hey I remember that one"
Lou	"he looked pretty pleased with himself"
Lea	"sometimes it's confidence isn't it"
Lisa	" they seem to really enjoy using that Numicon they love achieving…their self-esteem is immediately raised and that makes their behaviour better in the classroom" "a very quiet girl easy to miss that she's missing things…but now she's hands up she answers…it's so lovely to see the difference she's got her self-confidence"

Table 4-15 LSAs' observations: pupils' well-being

These comments on well-being ranged through general use of tools, learning specific concepts, to having tools available in the classroom in order to participate in class. From the LSAs' perspectives the tools were conveying obvious advantages to the pupils' self-confidence and self-worth. The tools were also having a positive effect on the LSAs' feelings.

Trudy pointed out another emotional effect of tool use in teaching: tools were important for engendering pupils' interest:

> "where the best teaching's going on the resources and things are drawing the children in"

In the three wishes section of the interviews, tools featured regularly as spontaneous expressions of desire (Table 4-16).

Tools: Pupils' wishes	
Preston	"one would be to have the Numicon with me more cos I don't normally have it all the time"
Peter	"more ways to do it so that you could choose your own way of doing it"
Penny	"more Numicon"
Poppy	"more making and building and doing things"
Paul	pointed to the picture of tools and said "ok"
Tools: LSAs' wishes	
Linda	"I think resources are invaluable…if you have got the resources it does help"
Lydia	"I suppose resources…we've got a lot of resources and they're good resources"
Liz	"equipment…and generalized use of the equipment"
Tools: Teachers' wishes	
Tess	"money for resources…there are some things that work really well"
Tracy	"more money for resources class set resources so that we have enough concrete things to help the children"
Tyra	"having the resources available for children all the time"
Toby	"lots of money for resources because they definitely need it"

Table 4-16 Three wishes

From the viewpoint of the pupils if they feel happier using tools and want more access to them it seems sensible to take heed of what they are saying. From the perspectives of the SEN Code of Practice and Children's Human Rights (DfE, 2015a, UN 1992) they have a right to have their views listened to and respected. The LSAs noted the change in well-being for these pupils, and the teachers were in support of having more resources available. Gifford and Rockcliffe (2012) support the view that the learners' emotional well-being and self-image is important in becoming a successful learner of mathematics. This finding that the use of tools can support well-being is therefore an important consideration,

especially in relation to the emotions that the pupils in these interviews described.

A strong picture is painted of the positive feelings associated with the introduction of pedagogic tools; unfortunately, the converse also applies: negative effects when they are later taken away. Toby described how he used pizza images to teach fraction concepts and observed that:

> "taking away the visuals it's definitely panic"

There were though comments about the use of tools that have implications in terms of how they are framed for both teaching and support.

4.6.2 Social/Cultural Associations

One teacher, Tom, was conscious of tool use having negative connotations which affected pupils' feelings about themselves.

> "some are quite happy and will go and get it as a matter of routine…some of them regard it as a bit babyish or special needish and I think that's probably because we are not at the stage where we use it across the year group…we tend to use it more with the children with mathematical issues"

His comment about the perceived users of tools was reinforced by teachers and LSAS describing the pupils who used them (Table 4-17):

Tools: The users	
Tyra	"the lower ones" "quite low ability"
Theo	"very low ability"
Lisa	"fantastic with the lower ability"
Lou	"the lower ability children"

Table 4-17 Labelling the tool users

This choice of language did not come across in a pejorative tone but more as a short-hand label for identifying learners. The DfE (2011) uses the same language when listing teachers' professional standards, they must:

> "set goals that stretch and challenge pupils of all backgrounds, abilities and dispositions"
>
> (DfE, 2011, p.10)

However, this language, I suggest, may limit thinking about the pupils and tool use and culminate in an emotional effect on the learner, for instance Preston's embarrassment and Peter's denial of tool use. Liz, who had witnessed widespread use of tools in the classroom, and Linda, were conscious that tool use could single out the user unless there was widespread acceptance of it (Table 4-18).

Tools for all	
Liz	"it's been really good for the children…who might have been a bit embarrassed using it now they're not because they've actually seen their higher ability friend using it as well as them"
Linda	"the worst thing you want to do is get this bright coloured stuff out…but I think if it's being used by everyone then no one's going to bat an eyelid and I think that's what we need for it to happen"

Table 4-18 Tools for all

Linda celebrated the times when she had seen this handled well. She described how she had heard teachers in some classrooms tell many pupils to "get the Numicon out".

Liz pointed out that tool use could have benefits for more than the pupils with SEN and MaLD:

> if it was just part of your learning of mathematics to have a tool there as opposed to … it's the less able children that use it it would be interesting to see how more able children could actually use it to their gain as well"

4.6.2.1 Discussion

Here it has been shown that using tools has improved well-being among LSAs, they were very positive about using them and observing their impact on the pupils. They remarked on both the improvement of pupil well-being: being pleased, feeling safe, and on the growth of confidence. In one illuminating reference, Patrick identified the effects of his memory book in his feelings of pride and improvement in mathematics.

There has been some research into the effects of tool use on student attitude and behavior, Reed, Drivjers and Kirschner, 2010, found an improvement in enjoyment of mathematics when 12-14-year-olds used a computer programme; however only one of their participants was described as having mathematics anxiety. Here I add to this knowledge with the argument that tool use by younger pupils with SEN and MaLD can promote a sense of well-being and confidence in both pupils and LSAs.

However, the use of tools was problematized for some by the connotations of usage. There was a general description among staff that they were available for the “low ability” pupils, rather than for learners with a need for a different access to mathematics “using special pedagogical devices” and finding a “roundabout path” (Vygotsky, 1993, pp.131 and 83). Vygotsky argued that learners with SEN are often placed in a different social relation to their peers which can in turn affect their behaviour: “a biological defensive armour against environmental conditions” (Vygotsky, 1993.p. 38). It seems that if tools can positively affect well-being and self-confidence among pupils then we should acknowledge their

effectiveness in improving enjoyment of mathematics and find a means of ensuring their usage without negatively labelling the users.

Tools in education I do not confine to the special pedagogical devices that pupils may manipulate to support their learning. I have chosen to define tools in a broader sense as the cultural instruments that are used to aid teachers' work, and government expectations. Here I define assessment as a tool and its implications in relation to feelings.

4.6.3 Summative assessment

Paul and Poppy both expressed their negative feelings about tests (Table 4-9) Theo observed the lowered attainment marks of some pupils who showed anxiety in the test situation, (Table 4-8). The literature bears out Theo's observation that the test situation itself can induce anxiety and the candidate gain lower marks than expected because of this emotion (Chinn, 2012, Maloney et al., 2013).

This raises questions about possible reasons for test anxiety, and how we can aim to make life more comfortable and secure for pupils in a test situation, in order that they can demonstrate their full capabilities, unhampered by excessive anxiety.

4.7 Summary

In this chapter we have seen how all the pupils and most LSAs have experienced and continue to experience negative feelings about mathematics and mathematics learning. The pupils all experienced confusion about mathematics which suggests a link between lack of understanding and this negative feeling. These negative emotions manifest in expressions of anxiety which were acted out

through various avoidance strategies, thus reducing the pupils' and LSAs' access to mathematics learning.

There was a decidedly more positive emotional response to the use of tools to support learning, expressed by pupils and LSAs. There was also a widespread desire for more availability of tools by teachers, LSAs and pupils. There are sociocultural considerations about the way that tools are experienced: who they are to be used by, and how these users are described. This suggests a need for re-evaluation by all involved in planning and delivering education, from government policy to the classroom, of how tools and their users should be identified within an inclusive educational environment.

In this data I have furthered knowledge of the experiences of pupils with SEN and MaLD through their own voices, as well as those of the adults who work most closely with them. These young learners articulate feelings powerfully and clearly, their persistent confusion being particularly highlighted, and explain their anxieties and behaviours around mathematics learning. The isolating social effects are here noted as Vygotsky had described. The socially isolating effects are also removing some of them from the mathematics learning environment (Paul leaves the room in anger, Peter can't ask for help). It is questionable whether anybody with such heightened negative emotions is truly available for learning. The pupils' anxieties about mathematics, and some LSAs' ongoing dislike of and anxiety about mathematics add weight to past research on the inception and continuation of mathematics anxiety.

This analysis leads me to ask how we might make life comfortable and secure for all pupils with SEN and MaLD in the mathematics classroom and what the most prominent factors may be that affect their lack of progress and personal discomfort in mathematics lessons.

5 MEMORY and MATHEMATICS

5.1 Introduction

In this chapter I examine the difficulties that pupils identify with memorization. I follow this with the recollections of LSAs and teachers about their own mathematics education. I look at teachers', LSAs' and pupils' beliefs and desires about the way mathematics should be taught and learned. I analyse my findings about the role of tools in memorization. Finally, I examine the place of the curriculum and assessment within the theme of memory.

5.1.1 Pupils' Experiences

When I asked the pupils what was difficult about learning mathematics 4 out of 6 chose remembering (Image 5.1) Penny was the only pupil to go into any details. For her remembering and understanding offered the same level of difficulty

> ""remembering really hard it goes with understanding"

She placed 'I do not understand' second because she wanted everything to show well in my photograph, the order therefore on her card is not quite as she chose. When Penny chose the card 'There are too many words to listen to' she pointed out that

> "when they speak too long I forget all the rest of the things and I might get confused a lot"

Here she was describing her difficulty in terms of memory (Image 5.1).

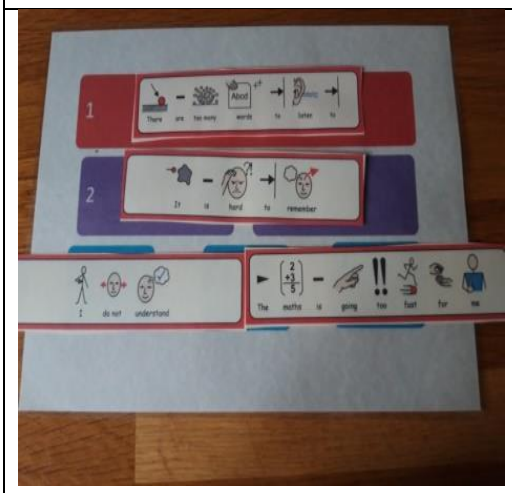
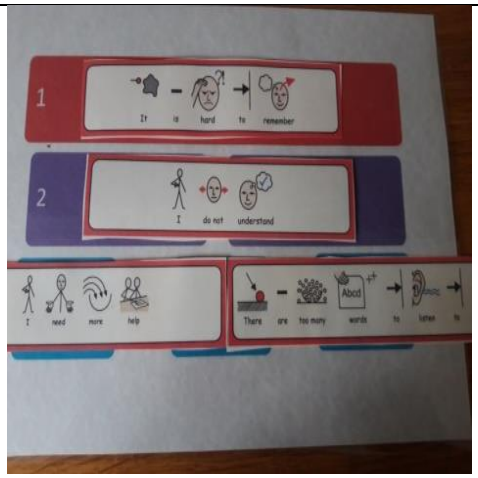
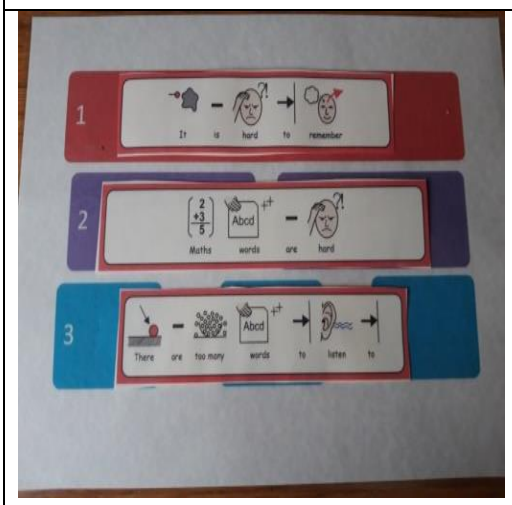
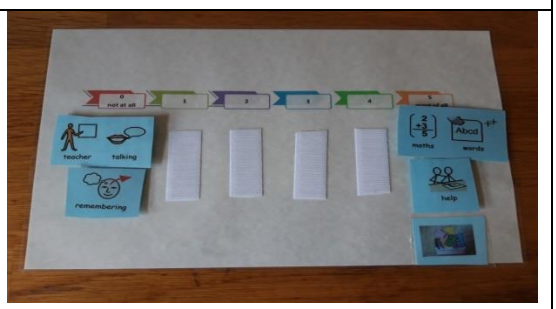
Pupils' views on what makes mathematics learning hard	
POPPY	**PENNY**
	
PAUL	**PATRICK**
	

Image 5.1 Pupils: what makes mathematics learning hard

I asked the pupils what they believed helped them in learning mathematics. The Likert scale started with 0 as not at all helpful to 5 most helpful of all. One of the cards the pupils could pick was 'remembering', which I explained as "practising to put the maths into their memories". Three pupils chose the remembering card, two placed it as no help at all, one as very little help These 3 pupils Patrick , Paul and Penny were 3 out of the 4 who had chosen remembering as a reason why learning mathematics was so difficult (Image 5.2)

Pupils' views on methods to learn mathematics	
Penny	
Patrick	

Paul	

Image 5.2 Pupils: most helpful and least helpful in learning mathematics

Here we can see that, for a proportion of pupils, memory and being required to memorise was a factor that they perceived as creating difficulties with learning mathematics.

The pupils' experience of difficulties with memorisation was not necessarily the same as the experiences that the support staff recalled about themselves; but in the LSAs' experiences memory difficulties were still sometimes apparent.

5.1.2 LSAs' Experiences and Beliefs

When I interviewed the LSAs they recalled their school experiences of mathematics as one of rote learning, that is, memorisation without reference to conceptual understanding. All described experiences like Lisa and Lou (Table 5-1).

LSAs' experiences of rote-learning	
Lisa	"we used to learn it parrot fashion" "quite basic you know your tables you learnt to count…know your 3 and 2 is 5 and 5 x 5 you could just say them"
Lou	"I was only ever taught column method…for addition subtraction…multiplication that sort of thing…I practised it from the moment I started learning mathematics…till the day I stopped…"

Table 5-1 LSAs' rote-learning

The LSAs did not describe these as bad or good experiences, simply as matters of fact.

They did, however, comment on the difficulties of memorisation that their pupils experienced. They recounted their observations of pupils: forgetting procedures, being unable to retain or recall knowledge in the longer term and forgetting maths facts (Table 5-2).

LSAs' observations of pupils' memory difficulties	
Procedural memory	
Liz	"they teach them the rules but I have to say even I can't always remember the rules…you know for the division rules…if you've got a good sense of recall then you're going to be not finding it such a struggle"
Long term retention or recall	
Liz	"might be doing it on the day" *but* "are not going to retain that knowledge to be able to do it independently"
Linda	"we've talked about it we've…almost done it to death and then we move on and expect the child to have remembered the lesson…the next week if we went back to it they'd probably go…we can't remember a word you said"
Lisa	"doesn't retain information…we have just repeated things over and over again"
Retention or recall of number facts	
Lydia	"the biggest problem is lack of knowledge of times tables "
Lisa	"now because they don't learn their times tables they don't learn their number bonds they still have to add on their fingers…and that is in year 4"
Lea	"it's the thought process of no I've got to count if there's 10 fingers I don't care what you say I've got to check it each morning"

Table 5-2 LSAs' observations on pupils' memory difficulties

Some LSAs recalled their own memory lapses whilst supporting pupils (Table 5-3)

LSAs' memory lapses	
Lou	"my own brain in the heat completely went…we were doing the grid method and we were doing something like 30 times 40 and my brain just would not work could not remember how many zeros to add"
Linda	"I just get confused with what are they called vertices and corners…I told them it was a vertice and they looked at me strangely so I said it was a corner and they seem to get it but I don't know if I've taught that right cos I'm not quite sure which is the right vocabulary"

Table 5-3 LSAs' memory lapses

Despite these memory lapses and their observations on pupils' memory difficulties Linda, Lou and Lisa expressed a commitment to, and belief in, rote learning (Table 5-4).

The LSAs' beliefs	
Lisa	"I mean I could go into a shop and I could use my times and…I know whether I'm adding up in a shop"
Lou	"they just need one way of doing things…and just practise that year on year" "there has to be learn the process before you understand the concept…they need to learn by rote and once you know how to do it by rote…you can then…think about the concept you are actually doing"
Linda	"the children don't necessarily understand…but they can follow the process…and they almost do it by rote…in some ways it is easier to teach"

Table 5-4 LSAs belief in rote-learning

Liz expressed a different opinion; she expressed the need for pupils to understand mathematics:

> "I think they are taught a method of getting from one place to another but I don't know…that they understand why they've done it "

She and Lydia both believed their mathematics had improved through understanding, (Table 5-5)

LSAs' understanding	
Liz	"when you sit and watch some of the children…you think actually I don't think I fully grasped that before"
Lydia	"watching the teachers I understand things like partitioning and expansion"

Table 5-5 LSAs' expressions about understanding

Two LSAs felt themselves to have learned more by understanding; three other LSAs appeared committed to rote memorisation. Lea was non-committal; she was the LSA who expressed the most dislike of maths.

5.1.3 Teachers' Experiences and Beliefs

Some teachers also described how they had learned mathematics by rote (Table 5-6).

Teachers' experiences of rote-learning	
Theo	"when I learned maths it was very this is the method this is how you do it this is the only way to do it"
Tom	"learnt to do the algorithms and jump through the hoops without really understanding" "felt very much that my mental maths was appalling I didn't have my times tables secure"
Trudy	"I did the process and got answers"

Table 5-6 Teachers' experiences of rote-learning

Teachers, like the LSAs, were aware of memory difficulties in their pupils with SEN and MaLD (Table 5-7)

Teachers' observations of pupils' memory difficulties	
Language	
Toby	"they seem to remember one key word for each operation and even if you mention it lots and keep going over it throws them completely"
Procedure	
Tracy	"you do addition … two or three months later you do addition again … by that time most of the children have forgotten"
Theo	"she couldn't remember how to add on a number-line I just thought we've done this over and over again and you can't now you've forgotten"
Long term retention or recall	
Tyra	"you'll be working with that group and you come back to it what within a week or a day's time they've forgotten it"
Toby	"you come back to it even a week later and it's not there and you think how many different ways can I show you"
Tess	"he will get somewhere in a lesson … but he doesn't hold on to it … you can come back to it in three weeks and its gone"
Retention or recall of number facts	
Tracy	"remembering multiplications because unless she does them to absolute death which she does have some practise on then it isn't in her head at all"
Trudy	"for some children memory plays such a huge part in the maths not being able to retain maths facts"

Table 5-7 Teachers' observations of pupils' memory difficulties

Tom and Tracy related memory difficulties to pupils having been diagnosed with SpLD (Table 5-8).

Teachers' observations: SEN and memory difficulties	
Tom	"often the dyslexic children I find even if they don't have any other maths issues they quite often can't learn their tables and things…they've got a recall issue getting things out sequentially"
Tracy	"she's got a very short very very bad working memory very bad short-term memory so she doesn't retain any facts…she does have speech and language difficulties…and hearing difficulties"

Table 5-8 Memory and SpLD

Tracy here had considered different types of memory and how poor memory functions could have an impact on an individual. Research in mathematics learning and memory implicates difficulties with short-term and working memory (Geary, 2004, Jonides et al. 2008) as Tracy states. It also includes difficulties with long-term memory and phonological memory affecting such processes as sequential memory for times tables as noted by Tom (Gathercole et al., 2004).

Finally, countering the LSAs' belief in rote-learning Tom and Trudy expressed their dislike of it from their own experiences of mathematics at school. (Table 5-9)

Personal effects of rote learning on mathematics understanding	
Tom	"I wasn't very confident with mathematics…in those days the mathematics text books still tended to follow the pattern that I'd been taught…learned how to do the algorithms but you'd never been taught to understand any of the underlying stuff…I would resort to an algorithm regularly…I wouldn't look at the numbers and think actually they are really close together so I will count on"
Trudy	"I came out of my GCSE…I wouldn't be able to tell you how I'd done I answered the questions but I didn't know if they were right or wrong"

Table 5-9 Teachers' personal effects of rote-learning

Tom, Trudy and the other teachers expressed their view that teaching for understanding was a more important practice in mathematics. I will now explore how the teachers described their teaching practice.

5.1.4 How Teachers Teach

The teachers expressed a commitment to understanding (Table 5-10).

Teachers' commitment to understanding	
Trudy	"I want them to have true understanding of whatever it is up until whatever they have reached…I really truly believe that they know whether they really understand"

Theo	*Celebrated when pupils demonstrated that* "I get this I get why we're doing this maths and I get why this maths is useful"
Toby	"I really enjoy seeing children making links between different aspects of mathematics…it becomes clear why they are learning maths and how it'll be used and those connections between concepts"

Table 5-10 Teachers' commitment to understanding

Some reflected on the difference that understanding mathematical concepts had made to them (Table 5-11).

Teachers: Understanding Mathematical Concepts	
Tom	"it was a complete revelation *(NNS,1999)* … being able to see the fact they broke down the algorithms into the prior stages" and "from that point I started to enjoy teaching mathematics a lot more" italics my own. It had "a lot of models and images stuff that was a lot more visual"
Tess	"it wasn't until I came into teaching decomposition that I actually got what I was doing"
Trudy	"the methods that children are taught…today have helped me to understand it"

Table 5-11 Teachers' personal effects of understanding

To help their pupils achieve understanding of mathematical concepts many described using methods that did not rely on algorithms, instead they preferred visual representation and practical scenarios (Table 5-12). Here Vygotskian signs and tools (Vygotsky,1978), and cultural settings are being used to aid understanding of more formal and abstract mathematics.

Teachers': Visual and Practical Methods for Pupil's Understanding	
Tom	"don't teach algorithms to those children get them to find a method that's visual they understand" "arrays for multiplying and dividing…because they could see what they were doing"
Toby	"draw a little image of what the problem is about if you drew the image it would help them understand which operation they are supposed to be using"

Tess	"division…I draw naked bald men *(stick men comically described)* for the number of people and then tally to count it" "finding the difference…between heights between children…what's the best way to do this…shall I measure the whole person and measure the next person and then take it away or shall I measure the difference"
Tyra	"fractions…I got them to play a game of handball and then afterwards record how many games they won how many games they played overall and put that into a fraction"
Theo	A topic…how we should invest money…for a school fair…you need to buy sweets…one supermarket's got buy one get one free one has buy three for the price of two what's the best…they just like I can see how I'm using my maths
Trudy	"looking at the difference getting out rolls of sellotape at the front so the one child was measuring out a load of sellotape and we had another child getting a different amount"
Tracy	"when we get money problems we get little shops with actual money and they come an solve problems"

Table 5-12 Teachers' visual/kinetic methods

These methods reflected not only the kind of teaching that the teachers spoke about enthusiastically, but it also reflected how they thought the teaching of mathematics ought to be: practical, relevant to the pupils' experiences and fun. The shop, handball and sellotape scenarios gave cultural significance to the mathematics, placed in context they encourage pupils to solve problems through shared activity (Kozulin,1990). The number work is placed in a meaningful setting.

5.1.5 Discussion

All of the staff that described personal educational experiences remembered mathematics as a rote learned procedure, several LSAs still espousing this method. Cockcroft (1982) in writing about the mathematics curriculum of the time had argued against this practice because it became a meaningless exercise. This experience of rote learning was not valued equally by all staff, with two teachers explicitly explaining how it had badly affected their understanding of mathematics. For these teachers the inception of the NNS (DfEE, 1999) had

improved their attitudes and understanding, whilst for two LSAs classroom support and observation had served the same purpose.

Ginsburg (1997) argued that the lack progress in mathematics in the US was partly owing to rote-learning. In my data there was a disjunct between the teachers' beliefs about teaching for understanding and some of the LSAs who believed that rote memorisation was important. Lui and Bonner (2016) had found that teachers with less time spent on formal qualifications in mathematics were more inclined to encourage and use rote-learning methods; I assume that this also to applies to LSAs.

Difficulties with memory, their own and observed, were spoken of by LSAs, teachers and most pupils. The memories spoken of were retention and recall of mathematics facts, processes and language. These memory difficulties reflect the results of memory research into MaLD: Geary et al. (1991, 2004) on retrieval of maths facts, Canobi et al. (2003) on procedures, Fuson, (1991) and Cowan et al (2005) on language. Most of the pupils included 'remembering' as an activity that made mathematics hard for them.

Most importantly was the absolute certainty expressed by the pupils that remembering mathematics was difficult and that memorising practice was not effective. Pupils with SEN and MaLD are here seen to be able to identify their difficulty, corroborated by staff, and identify the type of support that is unhelpful.

I went on to explore the effects memory issues and rote learning, were reported to have on mathematics learning.

5.2 Effects of Memory on Learning Mathematics

The interviewees described their experiences and beliefs about how memory difficulties affected the learning of mathematics. Three areas of mathematics learning were addressed here; I will look those areas separately: first number facts, then procedures and finally language.

5.2.1 Number Facts

Toby described how memory difficulties could over-ride all kinds of imaginative interventions for learning:

> "you're dividing by ten for example and you've gone over it and shown it through using arrays and how it all counts down and you've done columns and everything and you think they've got it…but you come back to it even a week later and it's not there"

One teacher spoke specifically about using rote learning as a strategy; to help memory problems with tables Tracy had found that precision teaching:

> "seems to go well with those children that do have poor working memories"

Tracy, however, pointed out that her pupil with hearing impairment, and DLD, was unable to remember her multiplication tables, even after doing them "to absolute death".

Nevertheless, the necessity for recall of number facts, described as a problem for pupils with SEN and MaLD by most teachers and LSAs, was usually described as necessary in order to access higher level work (Table 5-13).

The teachers' belief in recall of facts	
Trudy	"for some children the memory plays such a huge part in the maths not being able to retain maths facts and if you haven't got those at your fingertips when you get to larger calculations then it's just not there"
Tess	"you're building things…and you get that repetitive (clicking fingers) you know things off like that…once they've got that then they have the ability to move forwards"
Tracy	"things like measurement…there are known facts …she can't remember that one metre is a thousand millimetres which then stops her from doing everything else"
Lisa	"to learn the tables…it's one of those gaps isn't it…until you've filled that gap they won't move on … it's in everything isn't it"
Liz	"for the division rules it's almost an impossibility…you can see them all starting from scratch each time…some get to grips with your two times table your 5s and 10s"

Table 5-13 Teachers' belief in recall of number facts

The pupils described and demonstrated their difficulties with memorizing number facts, they were unsure of many times tables facts (Table 5-14)

Pupils' times table facts	
Paul	"easy 2, 4 10 that's it"
Penny	'impossible I know my two times table and my one times tables I don't think I know my ones, no wait ones is 12345 isn't it"
Patrick	"I only can do one cos one's easy 2s 5s and 11s and that's it"
Peter	"well sometimes tables are easier than others like 5 times tables, 8 and 9 is hard"

Table 5-14 Pupils on times table facts

Regarding addition Penny told me she added on her fingers and showed me 26 plus 4, her answer after whispering to herself was 31, demonstrating no recognition or recall of number bonds to 10.

Poppy told me:

"I don't know some of the addings"

She also spoke of her work in tests and class as 'guesses'. For instance she showed me some work on time, I commented that she was working on minutes and seconds *"Oh you've got to tell us how many minutes and seconds there are in 90 seconds"* and she replied "I didn't do that one I guessed and I got it right", she had also guessed that there were 30 seconds in a quarter of a minute. Here she is demonstrating that she has some memory of the numbers associated with time without accurate fact recall.

5.2.1.1 Discussion

Here lack of mathematics facts recall is presented by the teachers and LSAs as preventing progress into higher levels of mathematics work. The pupils' low level of number fact recall was apparent in what they reported and demonstrated; their memory difficulties were acknowledged by staff. The necessity for number fact recall is not clear from the literature, Geary, Hamson and Hoard, (2000), for instance, examine number fact strategies in order to examine and establish a cognitive link in some pupils with both memory and mathematics difficulties. Baroody (1984) called for numbers, instead, to be understood in meaningful relationships either algebraic or verbal.

5.2.2 Procedures

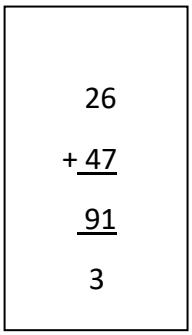
Here I look at the mathematical activity of finding a solution to a problem by following a sequence of actions, for example addition in columns, long division and grid method multiplication. These sequences are logically connected to mathematical concepts; however they can be taught as a process that has no recourse to conceptual understanding (Skemp 1987, Hewitt,2001). Memorising

procedures in their efficient and shortened forms can appear to be a formula to pupils who have not had the time or opportunity to understand how they function.

Penny was enthusiastic about demonstrating her ability with adding. She had told me

> ""on adding I'm 100%"

She gave me a demonstration and the solution she arrived at was:



She showed the use of regrouping using the column method but either misunderstood place value, or inadvertently reversed the numbers while writing, to arrive at an incorrect solution. I repeated to her that she had arrived at 13 as the answer to 6 plus 7 but this did not alter her answer, suggesting a memory of the algorithm but not yet able to apply conceptual knowledge of place value to check the answer.

Patrick explained difficulties with the grid method for multiplication:

> "you put two lines here and two lines there and I think like you put the nought at the corner and that's like too hard they do it but I don't get it"

He was placing a zero through memorisation but he had no numbers to work with at this stage. It was a rote action with no context or understanding.

Patrick also told me about his difficulties with subtraction, "I get all mixed up when I'm going backwards it's on a number-line I've done a hundred what's a hundred take away nine I get all mixed up then". Here the process was not secure for him suggesting a conceptual difficulty in understanding the number-line and how to use it; additionally his lack of recall of number bonds prevented him using that as an alternative approach.

Rote learning also appeared to prevent some using reasoning to understand the problem (Table 5-15).

Effects of memorised algorithms	
Tom	"when I started teaching I would resort to an algorithm regularly I wouldn't look at the numbers and think actually they are really close together so I will count on" "with things like addition and subtraction as far as I was concerned every time I moved up a column I was dealing with single digits"
Lou	"I know that it never taught me how to understand place value" "I had to sit there and do it column method…right ok I can do that and I know this is right cos I done it my way and I wasn't taught to do it this way at all"
Lydia	"all I know is column method…when you teach them that way *(partitioning and expansion)* I find it more confusing to explain"
Linda	"I'm just thinking about how easy I find things like adding and subtracting …cos there's a process...and I think sometimes the children don't necessarily understand the mathematical thinking but they can follow the process and therefore learn the process and they do it by rote"

Table 5-15 Staff on effects of memorised algorithms

5.2.2.1 Discussion

By concentrating on learning procedures by rote there was difficulty for the pupils when they could not remember every element of the sequence. Patrick and

Penny demonstrated difficulties with trying to act on procedures that they had memorised in some form but did not have the mathematical concepts to underpin the correct application of them.

Some LSAs appeared hemmed in by rote procedures that could give a correct answer but had not helped them to understand or explain the mathematics to the pupils. They described finding it difficult to explain and think in, for them, new, more conceptual, methods. Vygotsky (1998) had argued that using understanding to learn was a higher psychological process and therefore worth pursuing.

The teachers were focussed on understanding (Table 5-10) however there are indications that learning some procedures by rote is still a mathematics learning practice.

5.2.3 Language

Memory of language had also proved to be a difficulty for pupils with SEN and MaLD. This was of two types, remembering everything the teacher had said and secondly learning specific technical language. Five of the pupils, Penny, Paul, Preston, Patrick and Poppy identified that both areas of language were difficult for them (Image 5.1,Table 5-16).

Pupils' comments on difficulties learning with language	
Poppy	"sometimes she says that I should have been listening and I was and then I couldn't remember what she said" "maths words yeah I always think that I don't know what it means"
Penny	"normally when they speak too long I forget all the rest of the things and I might get confused a lot"
Paul	*one of his three wishes* "more help with the words"
Preston	"the teacher's talking through it and sometimes you get a bit confused

	what she's talking about"
Patrick	"teachers talk and talk about maths and I just oh boring … when they give me too much information in one I can't remember that"

Table 5-16 Pupils' comments on difficulties with language

Language difficulties were also displayed by the pupils as they spoke to me (Table 5-17).

Pupils' Expressive Language Difficulties	
Poppy	"point numbers" *for decimals* "I don't know what it's called" *for volume* "I added some numbers like 12 times 1"
Patrick	"if you've got a thousand like times er not times add like a thousand um I sometimes when I forget like thousand times um not times add something"

Table 5-17 Pupils' expressive language difficulties

Poppy displayed an imprecision in vocabulary that may reflect a difficulty with expressive and/or receptive language. Patrick told me measuring was difficult because of the words. He could demonstrate the categorisation of the type of numbers associated with metric measurement but their definition and application are not complete.

> "is it a centimetre metres and centimetres meter is like ten or is it ten twenty or is that centimetres"

I asked Patrick what a metre looked like if he used his arms, he ignored this and continued to try and define the words by using number, as rote learned facts, rather than using any visual representation as support.

He also had difficulty in the sequencing of language:

> "January February March April *(pause)* what's the first one again

Many teachers commented on the impacts of speech and language difficulties on learning mathematics (Table 5-18)

The Impact of Developmental Language Disorder	
Trudy	"the language is very abstract often the words we're using are words that the children hear in everyday language but difference it's a classic one isn't it what's the difference between these numbers one big and one small you know that's got a wobble in it that's got a straight line that one's in blue that one's in red" "the difficulty of accessing the lessons understanding what the teacher's saying and being able to express themselves that being able to reason things through"
Theo	"shape they never say ooh I just walk around the vertex there's a whole vocabulary of shape we just never use in everyday lives…it's so discrete and so specific… they have no idea what they need to do"
Tess	"it's how you understand the world isn't it through concepts so unless you've got the understanding of the language you'll never get the maths"
Toby	"lots of children get stuck on times multiplication you say product that throws them completely they seem to remember one key word for each operation and even if you mention it lots and keep going over it throws them completely"
Tracy	I would have a thing with why aren't they accessing and a lot of it is just because of the technical language that is used"

Table 5-18 The Impact of Developmental Language Disorder

LSA, Linda, described this as a difficulty for herself.

> "I just get confused with … what are they called vertices and corners and things like that"

Here the memorisation and definition of technical terms and remembering teacher's instruction was described as a difficulty by the pupils, and about the pupils. Research has shown that these are known difficulties for children with Developmental Language Disorders (Dockrell and Messer, 1999, Chiat, 2000, and

Martin and Miller, 2003). The difficulties may also occur because of memory difficulties within the phonological loop (Gathercole et al. 2008).

What is of note, again, in this section is the ability of the pupils to speak for themselves and to identify their own difficulties.

5.2.3.1 Discussion

This section has highlighted the effects of the difficulties with memorisation that pupils experience with number facts, procedures and language. The impacts are on maths progress (Gathercole et al., 2004, Geary, 2004, Jonides et al. 2008) and teachers' and LSAs' statements concur with these findings. What is new in this research is the proof of the ability of these young pupils with SEN and MaLD to identify their own difficulties within their mathematics education.

Vygotsky described logical memory as one of the higher psychological functions, a memory that could be harnessed to such skills as reasoning, conceptualisation and comprehension (Vygotsky, 1998). He argued that pupils' difficulties with a natural psychological process, of which memory is one, would impact on their cultural development (Vygotsky,1993). It thus seems appropriate to consider 'special pedagogical methods' and 'special cultural tools' (ibid. p.47) that might bypass a proven memory difficulty in order that the pupil can progress in a mathematics education.

I next explore the implications for pedagogy with regard to memory difficulties in the use of tools, teaching and support, and assessment.

5.3 Implications for Pedagogy

It was clear in chapter 4 that tool use was associated with well-being and pupils, LSAs and teachers would like more resources. I now investigate what evidence there is that tools can also aid memory.

5.3.1 Tools in the Classroom

The pupils gave some evidence that this was indeed the case. Patrick had a memory book. It is worth repeating what he told me:

> "I've got this memory book now and I just write the important stuff what they say now write it down and then I just open the book and I say oh ok yeah"

Patrick was so enthusiastic about his memory book that when we used a Likert scale to think about what helped when he learned mathematics, he put the memory book beyond the scale, "it will go six". I had not anticipated a memory book as a tool, so we improvised one with post-it notes that I had taken with me (Image 5.3).

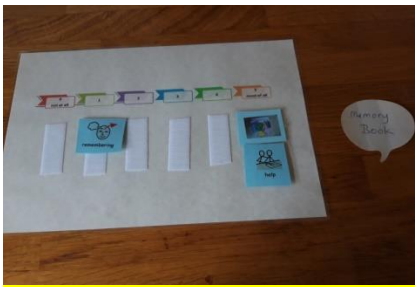


Image 5.3 The positive message of Patrick's memory book

The pupils' comments on tool use were universally positive, only Peter had nothing to say about them as he told me he didn't use any. It may be that he couldn't remember any at this point in the interview (Table 5-19)

Pupils' tool use for learning	
Poppy	"there's the shapes with the circles in like 1 2 3 or 5 6 7 8 9 10 they help sometimes there's pegs as well"
Paul	"Numicon yeah that helps"
Preston	"like first we all have to try and think getting using different numbers on the Numicon board and then we use Numicon like rulers and we have to try and get to a certain number with using like 10 plus 6 and find out the answer for that … I like doing that it helps"
Penny	"it helps me all the time when I use Numicon I know how to divide and add with it I know sometimes times and odd and even"

Table 5-19 Pupils' description of tool use

Here we can see tool use to support memory. Poppy speaks about the circles and pegs; these are used to access number facts of addition and subtraction. Preston explains an alternative method of addition, creating a number-line with Numicon. When Penny told me about knowing odd and even, I asked her how she did it. She explained:

> "if they've got one more it's an odd and if they haven't got one extra one it's even"

This does not show understanding of the principle of being able to divide by two but "having an extra one" is an image of the type of number that 'odd' represents. We had no Numicon to hand so I asked Penny if she could 'make a picture' of Numicon in her head to tell me whether 17 was odd or even. Her reasoning follows below.

"they don't really have 17 … oh yeah …ten and a seven"
So that would be odd or even
odd and even
why would that be
oh it's odd odd
why's that go on you're thinking well
cos it's got an extra one
yeah how did you do that … what did you do
cos I say this in my head and there isn't really one shape and then I said oh yeah ten and seven …
and then how did you decide it was odd
cos it's one extra"

Here Penny had used Numicon enough that she was now able to visualize it. She also used image to talk about the shape of an odd number, and was able to reason using place value, a 10 and a 7.

Lydia had described Penny, who she supported a year ago:

"I think a number to Penny you know what's a 3 what's 13 I don't think she really fully understands even though I did get the dienes cubes out and I physically showed her … I don't think she's quite there with the whole number system … I think with her she can't see that in her head it's a number on a piece of paper"

A year later Penny had moved on and could certainly see and reason with 10 and digits.

Some LSAs had noted the visual properties of Numicon. This is likely to have suited the pupils' learning preferences; the visual and kinetic properties that can relieve the burden on phonological memory (Baddeley, 1997) (Table 5-20).

LSAs: Tools that Support Memory Functions	
Linda	"I really like *(it)* because it's visual and things like taking away you can have the whole number in front of you and you get the parts and you can almost see it being taken away or it's missing…it's a brilliant resource"

Lou	"I worked with Priya…she hadn't got much concept of place value…being able to see the shapes and the blocks and being able to put them on top of each other and next to each other…it clicked an awful lot clicked"
Lea	"she could count to 10 but as soon as you started working with the numbers up to 10 all of a sudden she had this blank so we got all the numbers out…and we'd go now how can we make 10 so I'd say put the 9 on top she'd say well one and all of a sudden that's obvious…it was a finger job counting to 9 as soon as she used the visual…putting on the 8 she'd say it's a 2 the 7 it's 3 she could see it so it was great"

Table 5-20 LSAs' comments on visual impact of tools

It is useful to here to compare the activities that the pupils said that they enjoyed and did well in; here it can be seen that they favour, and can succeed, with the visual(Table 5-21):

Pupils: Visual in Mathematics	
Preston	"on the table we were given some shapes and we had to put them in diagrams we had to make it up like how many corners appear in the shape and we counted them…we could decide what we wanted to do we did a Venn diagram"
Peter	"charts we did it in a booklet it was a thick booklet and it had a chart running and it looked really easy I was happy cos I could do it"

Table 5-21 Pupils comments on visual mathematics

Teachers added to the approval of the use of tools to aid pupils' progress when rote memorization of number facts and formal procedures could be foregone and understanding become the focus (Table 5-22):

Teachers: Tools that Support Memory	
Tom	"my classic one with Numicon is Paul who has learned to do all 4 methods using Numicon…division he would lay the number out and then lay what was the divisor on top so if he was dividing by 4 he would lay all 4s on top to cover the complete number and then he's able to see how many 4s he had and what the remainder was …we even got to the stage where he was doing a bit of problem-solving … they had a triangle and the gap…you had to work out what the other number was using Numicon you could do that"
Tracy	"the concept of division…dividing by 5s putting the 5s on top seeing all those and 2 left over…I try and think how can I do this apart from sharing which obviously

	division isn't always sharing…here they're getting inverse so that's really helped their multiplication too"
Tess	"just looking at factors…Numicon again is good for that we did an investigation into consecutive numbers and yeah Numicon was…good"

Table 5-22 Tool Use to Support Memory and Understanding

Here the pupils are accessing the visual-spatial sketchpad of their memory system (Baddeley, 1997) and appear to be much more comfortable with this approach.

For language support several described the use of vocabulary displays in the classroom (Table 5-23):

Vocabulary Support	
Theo	"I've got this display up here because they don't understand lots of the … vocabulary for the operations so look…what's the total what am I doing"
Toby	"for the autumn and spring term I had all the different vocabulary on the board"
Tess	"they get thrown by questions because of the wording…it's having that on the wall in a particular place is going to help"
Linda	"teachers always…have big displays of these words mean add and these words mean take away"

Table 5-23 Language support posters

It seems then that tool uses as described by Vygotsky, (1993) remains an important means of access to mathematics learning but can also now be considered as a 'special cultural tool' that allows pupils with SEN and MaLD to access learning that is readily available to their typically attaining peers.

In regard to being able to learn mathematics teachers noted that several of their pupils with SEN and MaLD were not weak in all topics in mathematics(Table 5-24):

Pupils' skills in mathematics	
Theo	"those that are low ability in other areas of maths aren't necessarily low in telling the time"

Trudy	"there's some other aspects of maths where children can be flying and equally bright children come under…dyspraxic child a few years ago brilliant with number when it came to co-ordinates and plotting…couldn't do it for love nor money … this child was absolutely distraught"
Tess	"the difference between his linguistic abilities and his maths abilities was hidden…he can do the linguistic side where he's average…it's his number his spatial stuff is good…but it's his number"
Tracy	"Paula … counting above 15 there are days when she can't even get above 10…but when we do data handling she's set up her own investigation she drew up her tally chart she went around the class carried out the investigation changed it into a pictogram showed me as a bar chart…and then was even asking questions about the data to have that real understanding then you wouldn't have seen a difference at all between her and anybody else in the class"

Table 5-24 Pupils' skills in mathematics

Ginsburg also made this point:

> "A cognitive "defect"… may prevent a 6-year-old from memorizing number facts but may not interfere with his or her use of money or with geometry"
>
> (Ginsburg, 1997,p.30)

Variations in skills suggest that low-attainers in mathematics may be struggling unnecessarily, and some of this could be attributed to memory difficulties and the need to memorise. Penny demonstrated how tool use had left a visual impression that allowed her to reason with tools that were no longer present. Not all pupils were able to achieve visualization; some needed the tools with them to continue accessing the number work: (Table 5-25).

Pupils: Continual Tool Use	
Tom	"he would never be able to do that if it was just numbers he had to do it with the Numicon because he could see it straight away"
Theo	"we've done this over and over…now you've forgotten it all…gone back and got out the apparatus again she went oh yes I do know what I'm doing"

Table 5-25 Pupils' continual tool use

Theo's pupil had not forgotten but she could not recall; she merely needed a visual prompt to her memory system. This demonstrates that the pupil had more ability to succeed than she was able to demonstrate using formal, abstract mathematics. However, whether the pupils were visualizing or handling the tools, progress and understanding was being demonstrated.

5.3.1.1 Discussion

It has been demonstrated that tools are a cultural device that can offer pupils "roundabout paths" to mathematics work based within higher psychological processes of logical memory. The tools were found to bypass the need to memorise number facts and were able to support memory for procedures. Additionally, tools aided understanding. Here the social and cultural management of the learners' mathematics education is achieved enabling pupils with SEN and MaLD work within their higher psychological functions (Vygotsky, 1993)

Some pupils required continued access to the tools in order to work at this level, others needed them temporarily in order to understand an abstract concept, and/or until they able to visualize a number fact or process. Teachers and LSAs were universal in their praise of tools to facilitate progress and support for their pupils.

A notable addition to the findings is that the pupils, again, were able to speak for themselves; they liked tool use and could identify the tools that were of particular help to them.

I will now explore the implications of memory and tool use on teaching support.

5.3.2 Pupils' Alternative Needs

If we listen to the pupils, understanding is important to them. They spoke about difficulties they had in certain topics in the same context as saying they didn't understand it (Table 5-26).

Pupils': Understanding	
Preston	"when we first came into school the sheets were lying on our tables and I can't really do dividing I don't really understand it"
Patrick	"you put the nought at the corner and that's like too hard they do it but I don't get it"
Peter	"the decimal ones we had to put them in order and it didn't make sense cos four is higher than zero point twenty five or something"

Table 5-26 Pupils on understanding

There was no expression of not wanting to learn mathematics from the pupils. Several of the pupils expressed their desire to be good at maths, with an implication that they would like to understand it. Penny wished:

> "To be the bestest at maths in the whole world"

but her self-deprecating tone and rueful laugh made it clear that this was far from her present truth.

Two of Patrick's three wishes were for:

> "A better brain and I need to listen more"

This suggested that he counted his difficulties with mathematics as owing to his own cognitive failings.

He also told me:

> I'd actually be quite good if I could understand"

Peter wished for:

> "more ways to do the maths so you can choose your own way"

This was an interesting and thoughtful reflection.

The environment in which this can be achieved must be considered.

> "we cannot consider… *(cognition)* apart from the many contexts in which it operates. To understand the child's failure we need to consider how his or her cognition functions in its context"
>
> (Ginsburg, 1997, p.28)

5.3.3 Teaching and Support

Two interviewees commented that tool use was accepted as a temporary measure and had to be removed from the pupils: (Table 5-27)

	Managing without tools
Lisa	"at the moment I'm doing Numicon and in the classroom we try not because we've got to try and wean them away obviously"
Tracy	"when it gets to things like tests and even with Numicon now they're not allowed to use apparatus or their number square or like the number beads…we are all the time saying get your apparatus us encouraging them 24/7 to have visual things in front of them and then go oh no you can't have it and taking it away"

Table 5-27 Managing without tools

Lisa's comment about weaning pupils from Numicon can be understood in light of Tracy's statement about examinations. Here there appears to be a point at which collision of principles in mathematics learning and teaching occurs. The tools that can aid memory and understanding are removed from pupils in order to prepare them for examination conditions. At this juncture it may come as little surprise

that teachers and LSAs favour the ability to memorise number facts(Table 5-13, Table 5-4).

5.3.3.1 Discussion

The pupils gain confidence and success from tool use but are simultaneously preparing for the tools to be taken away. This is possibly proving to all that tool use is a method for those of "lower ability" (Table 4-17). The pupils are returned to their unreliable memories and their ensuing results persuade them that they are not good mathematicians. In Patrick's case his own fault in needing a better brain.

Dowker et al. (2012) found that pupils liked or disliked mathematics on the basis of their beliefs in their own progress. Here these young pupils' opinions move away from a like/dislike to continuum to show a deeper desire to understand and do well, despite their difficulties. These are difficulties which they are able to recognise and explain.

I will now consider how the curriculum and assessment regard memory.

5.3.4 Curriculum

Vygotsky argued for a society where children with difficulties in any natural psychological functions would learn to use tools that would aid their development. The teachers' belief in the necessity for rote learned facts however may reflect the demands of meeting curricula requirements and an exam system that expects proof of memorisation (DfES, 2006, DfE, 2013).

Here sits a barrier for children who have memory difficulties. Within the NC (DfES, 2006) there was an explicit inclusion of memorization; replicated in the current NC (DfE, 2013). The National Curriculum (DfES 2006) in use at the time specified

the memorisation of number facts, for example 7 – 8-year-olds should "recall all addition and subtraction facts for each number to 20" (ibid. p.76) and required language recall: 10 -11-year-olds will "use correctly the vocabulary…for lines, angles and shapes" (ibid. p.85). They will also "use standard column procedures to add and subtract integers and decimals" (ibid. p.84). These skills were to be examined in SATS tests towards the end of year 6 thus teachers were obliged to respect the curriculum objectives.

Tom spoke about memorising when he commented:

> "there are some children who are never going to be able to do that…you've got to think what can we do instead that will enable them to use this mathematics usefully in life"

Here he echoes Vygotsky's account of our cultural norms belonging to those with typical psychophysiological development.

5.3.5 Assessment

Here there are two areas of interest, the first is with assessment of the pupil through curriculum objectives and secondly the availability of access arrangements.

The culminating focal point of primary mathematics education is, currently, the SATS tests at the end of KS2. The curriculum objectives above show that memorization is expected and will therefore be one of the concerns of teachers and LSAs in their education of all pupils.

Secondly there are assessments for access arrangements. These do acknowledge some memory difficulties, allowing for extra time, alternatives to handwriting and

a reader in mathematics examinations (Standards and Testing Agency, 2018c). The use of tools is not permitted, this is accounted for as possible "unfair advantage" (Standards and Testing Agency, 2018c, p.22).

Thus in at least some of the SATS testing, it is the pupils' memory abilities that are being tested, rather than their mathematical abilities.

5.4 Summary

The teachers, LSAs and pupils all stated either current difficulties with memory or observations of pupils who found it hard to memorise. The effects of memory difficulties are not confined to a difficulty with remembering times tables or number bonds, they are apparent in recall of procedures and speech and language. Teachers and LSAs view this lack of ability to memorise as preventing pupils from participating in higher level mathematics work. Researchers such as (Geary et al., 1991, 2004, Seethaler, Fuchs, Star and Bryant,2011, Gathercole et al. 2008), have found that difficulties with the phonological loop, and/or working memory, can cause mathematics and language difficulties.

The LSAs and most teachers had been taught within a system of rote-learning. Several LSAs viewed this memorisation style of mathematics learning as useful (Table 5-4). Most of the same LSAs did not value themselves as competent mathematicians and thus seemed to view rote-learning as the only alternative (Table 4-10). Their advice that pupils should do the same seemed to place the pupils into the same world of rote recall and lack of self-belief.

However, for those pupils with SEN and MaLD for whom retention and recall of mathematics facts is a real problem low mathematics attainment could be viewed

as a symptom of a weak memory system rather than low ability in mathematics. Teachers observed that pupils with SEN and MaLD were capable of achieving in certain areas of mathematics (Table 5-24). Dowker (2009) pointed out that this spread of strengths and weaknesses in mathematics attainment is not unusual for pupils with mathematics difficulties. It would be wise then to refrain from labelling pupils as low in ability because their attainment is lower than their peers, without them having the opportunity to prove their understanding or indeed have access to higher levels of learning (Table 4-17).

Vygotsky (1993) argued for adjustments in education through the use of psychological tools. Teachers and LSAs commented on the way that certain tools allowed the pupils to bypass memory through visual and kinaesthetic learning. The pupils, LSAs and teachers found that tools also aided their understanding of mathematics. However, there is an acceptance that tool use cannot be a permanent solution.

One cultural position that exacerbates or indeed creates a mathematics difficulty for pupils with SEN and MaLD is the social expectation that memory is necessary to be a good mathematician. Here we find a possible reason for the belief that tool use cannot be permanent. The demands of the National Curriculum for mathematics support memorisation (DfES, 2006, DfE, 2013) as do the assessment procedures that accompany it.

From a Vygotskian perspective the pupils' memories difficulties are frustrating the development of higher psychological functions, in reasoning and logical memory,

because of a clash with cultural norms. Here the cultural norms that are enacted in the mathematics curriculum.

In this section, it is notable that young pupils with SEN and MaLD were able to articulate their specific difficulties with mathematics learning, describing what helped them, and what didn't. Pupils have also stated their wish to do well in mathematics and to understand it, their motivations and feelings thus enriching our knowledge further than a like/dislike continuum based on self-perception of attainment.

6 TIME

6.1 Introduction

Time was the third theme that permeated the interviews. In this chapter I explore the different ways in which time was articulated as a factor that influenced the mathematical teaching and learning experiences of the participants. I begin by considering expression that reflected their feelings and beliefs about the role of time. I go on to look at emotional responses and effects on learning. Finally, I explore the implications for pedagogy in the use of tools, and teaching, support and assessment methods.

6.1.1 Pupils' Experiences and Beliefs

Three pupils spoke of pace as an issue. For Peter this was a major theme, choosing two cards about pace. Peter and Poppy both chose the card "The maths is going too fast for me", for what makes mathematics learning hard. Here they made it clear that it was the lessons and their content that were too fast for them (Table 6-1)

Difficulties with pace	
Poppy	"there was like these shapes that we had to put it on paper and then just doing that too fast and everyone went and done it then I went with *(LSA)*"
Peter	*He wants to cry* "when I just can't do it it's like times and dividing and I can't do it and you have to do it like in 60 seconds hour or something and you have to do 10 sheets and it's really hard"

Table 6-1 Pupils' difficulties with pace

Here I gain the impression of Peter feeling thoroughly overwhelmed. Additionally, Peter, chose the card "I can't keep up", as did Patrick.

Patrick explained this further (Table 6-2):

Patrick's comments on pace
"if it would slow down you could get more time … it would be easier"
"if I'm thinking it'll take me quite long it'll take me like two hours"
"maths is quite too fast cos I know if I manage to finish the question it will help"
"remembering things is quite hard sometimes it just comes and sometimes I have to think quite long"

Table 6-2 Patrick's comments on pace

Here he is quite explicit that he needs thinking and working time. This can be linked to his speed of processing, retrieving long-term memory through the phonological loop and/or working memory (Gathercole and Baddeley 1990a and b, Baddeley, 2003, Wagner et al. 2013,). There is no question of lack of motivation here.

6.1.2 LSAs' Experiences and Beliefs about Time

The LSAs observed a pressure on time which they related to the speed of the curriculum (Table 6-3).

LSAs' observations on pressures of time in the curriculum	
Linda	"the curriculum is very fast paced"
Liz	"we're covering this we've got to cover this it's not the fault of the teachers it's the way the curriculum's set"
Lou	"things are moving on very quickly … in maths"

Table 6-3 LSAs on pressures of time in the curriculum

The need to cover so much in the curriculum meant that topic changes were rapid (Table 6-4).

LSAs' observation on rapid topic change	
Lydia	"I couldn't be more frustrated…we're doing expanded method now we're going to do division now we're going to do shape…now we're going to do time"
Liz	"you're doing area and perimeter then the following week you are off to do data handling"
Lea	"they're learning a new concept but within two weeks we have changed"
Lisa	"it moves on so quickly he's got some *(subtraction words)…* and then we're on to something else"

Table 6-4 LSAs' on rapid topic changes

6.1.3 Teachers' Experiences and Beliefs about Time

Teachers echoed the LSAs' concerns about pace brought on by the need to cover the curriculum (Table 6-5).

Teachers' observations on pressures of time in the curriculum	
Tracy	"in class it's… pace pace pace you've got to get them through this objective and this objective" "you're on division right let's now do fractions let's skip to something else"
Toby	"we move on too quickly you've got to cover so much these objectives"

Table 6-5 Teachers on pressures of time in curriculum

Three teachers described the pressure to make progress, for Toby the progress in each lesson was important. For Tess and Trudy it was the pupils' progress in the whole curriculum (Table 6-6).

Pressure to make progress	
Toby	"you know every child has to make progress in every lesson"
Tess	"I'm under pressure to produce children that can hit particular things at particular times"
Trudy	"what I do understand is this need to move them on as well *(as aiming for understanding)*"

Table 6-6 Teachers' pressure on progress

Whichever position the teacher was viewing from there was an implication, as Trudy stated, that pupils needed to be moved on.

6.1.3.1 Discussion

Here we can see that pace was specifically linked, by teachers and support staff, to the requirements of covering the National Curriculum It was also linked to the manner in which this was accomplished; changing topics too rapidly for pupils with SEN and MaLD to understand the topic sufficiently. Toby felt the pressure of needing to move on and make progress during each lesson. None of this was unexpected in the light of research (Leong and Chick, 2011, Haser, 2010). However, there was also a mismatch between the pace given to curriculum time and the pupils' need for more time.

For the pupils this affected their ability to complete tasks. Patrick was able to express his views on this very well, explaining his difficulties with recall. In addition, Peter was particularly negatively affected by the pace of mathematics that he did not understand but still felt pressure complete.

Vygotsky (1993) warned that negative emotions could become a secondary symptom of being unable to cope in an education that does not suit a pupil's style

of learning. The pressure on curricular time is having a disabling effect on their access, ability to complete and well-being.

The pupils have given a new perspective here on the effects of pace and reinforced their motivation. Patrick explicitly stated that he wanted to complete his work

6.2 Effects of Time issues on Learning Mathematics

6.2.1 Emotional Effects

Peter's comments throughout his interview revealed a child who was frightened and anxious about mathematics, for him a major concern was pace. The anxiety itself may be preventing Peter from showing his abilities. He also described the difficulty of the work; it is difficult to disentangle these two pressures on his emotions.

The emotional effects on other pupils were noted by some staff (Table 6-7).

Emotional effects of pace observed by staff	
Linda	"for some children you want it *(time)* almost to stop so that you can really embed it in them…if you move on too quickly it can scare children"
Toby	"they need a bit more time…*(speed)* could lead to low self-esteem because that child might need that extra bit but I still haven't achieved that bit"
Tom	"they'll do the long multiplication but if they don't know what six eights are…just bogs them down makes them think the maths is boring slow and tedious "

Table 6-7 Emotional effects of pace

Here a variety of reasons for the pupils' negative feelings were offered: concern that they have been moved on too quickly, the child's knowledge that they haven't achieved the target set and the mental effort of trying to recall

mathematics facts. These factors led to observations by the staff of fear, low self-esteem and loss of interest.

In addition to the insecurities and negative feelings described here, and expressed strongly by Peter, there were effects related to the pupils' access to learning.

6.2.2 Short-term Learning

Short-term effects of pace I here relate to the speed of doing tasks. Patrick recounted a lesson where he was working on timed mental mathematics; a challenge to any pupil who may have speed of processing difficulties:

> "I did times it's quite a hard one and it was mental maths work … it was like three thousand times twenty five million and like I had a piece of paper and it took me like half an quarter of an hour and I was like I give up and I guessed it and I got it wrong"

Patrick was unable to complete a piece of work, he was quite matter of fact as he recounted this tale but the messages he is receiving relate to having to guess rather than reason, his own failure and finally that mathematics is about memory and speed.

For the staff the speed of recall of number facts was considered a necessary building block of mathematics. Without this, pupil progress was perceived to be impeded.

Tess was very clear how important she felt speed of recall was for progressing in mathematics:

> "it's your building things with number bonds and you get that repetitive and *(clicking fingers)* you know things off like that…once they've got that then they have the ability to move forward"

Some staff expressed concern about the effects of lack of speed of recall of number facts during lessons and tests; below they describe how this prevents the pupils from achieving what they might (Table 6-8).

Effects of pace in lessons and tests	
Lydia	"they can do really well at something and then they're thrown because when they've worked that out *(times table)* they've forgotten what they're doing… they will need a number grid"
Tom	"they don't know their number bonds…if you've got to work out those things without them being instant recall then clearly it's going to take longer…before they can even attempt the rest of it"
Lea	"it's all about the numbers…the thing is often they can do the calculation work but they get lost and time's lost"

Table 6-8 Effects of pace in lessons and tests

Here their descriptions of pupils forgetting what they are doing and getting lost within a calculation appears to be a direct consequence of slow speed of recall.

Lisa, in addition, described the effects of pace on a pupil who had difficulty in processing incoming information:

> "he gets lost in the lesson…he's just got the first instruction…the number…than some-one's saying something else to him and he's lost what add is so you have to be very very slow"

Thus, the pressure of pace is described as affecting both the ability to process incoming information, and its recall. These, staff argue, affect the pupils' ability to move on to a higher level of mathematics using understanding and reasoning. Patrick explained this clearly from his point of view when he was under pressure to give an answer in a mental mathematics calculation and he guessed.

6.2.3 Long-term Learning

Here I consider the effects of keeping up with the objectives of the curriculum. The principle of understanding, a matter of importance to teachers as seen in chapter 5, was considered to be compromised.

Teachers and LSAs spoke of how the need to move on in order to fulfill objectives left gaps in the pupils' knowledge (Table 6-9).

Teachers' observations on pupils' learning at pace	
Tracy	"it's when those small steps get missed out… you might think that they are a lot higher than they are but actually things have been rushed past and missed out"
Trudy	"some children just get the grasp of one *(method)* and then they've moved on to the next and they don't realise that the two things might be linked…I didn't think that does any of the lower ability children any favours because they didn't really get to grips with anything"
Liz	"I think they get all the information but I just don't think they have time to get to grips with it and use it confidently"
Lisa	"you've got…four sessions for that…none of whether you've got it or not they move on so that person's immediately got a gap"

Table 6-9 Teachers' observations on learning at pace

6.2.3.1 Discussion

There were three main issues in mathematics learning when working at a speed that did not suit the pupils. For pupils like Peter, the pace, together with the size of the task, and possibly the task itself, was so overwhelming that his emotional responses could have been blocking his approach to the work. Teachers and LSAs had also observed emotional reactions in pupils working at a pace that did not suit them.

Secondly, on a daily basis, if pupils have to work at speed when they have slow processing as part of their memory functioning, they will not be in a position to

explore or show what they do understand. The staff viewed lack of speed of recall as affecting the pupils' ability to complete work in the time allotted (Table 6-8). We have already seen that recall is difficult for pupils (Table 6-1) now this difficulty is compounded by requiring recall at speed. Hewitt (1999) spoke of necessary information being that which could be deduced. Pupils can deduce many number facts but it is questionable here whether they have the time to do so. Speed of processing is a known difficulty for some pupils with SEN (Wagner et al., 2013). Penny for instance could deduce that 17 is an odd number but she needed time to reason, her knowledge wasn't automatic (pp. 174-5).

Finally, longer term problems were related to the speed of moving on from one topic to another which left pupils with gaps in their understanding and knowledge. Patrick had spoken of his difficulties with grid multiplication (pp.167-8) and in the process had shown his lack of understanding of the use of zero. If he does not have time to absorb this concept, he is unlikely to be able to find success in the type of mental mathematics question he gave as an example.

It therefore appears reasonable to explore the implications of time on pedagogy.

6.3 Implications for Pedagogy

6.3.1 Tools in the Classroom

Tools were described by teachers and LSAs as having an instant effect on pupils' rapid access to number facts (Table 6-10).

Tools for access to number facts	
Tyra	“number bonds to 10… with Numicon it fits…you get the blue ten out what other two can you make up with that and they can see it”
Liz	“subtraction he struggled with but when he had that tool to hand I was amazed at how quickly he could show me how he could do it just by being able to see the difference”

Table 6-10 Tools for access to number facts

Two LSAs compared the use of tools favourably with children using their fingers to carry out calculations (Table 6-11).

Finger use as tools	
Lisa	*Comparing with Numicon* “that’s a nine that’s a seven you put that on top…there’s a difference of two…they use their fingers but you know they see that immediately”
Lea	“how can we make 10…put the nine on top she’d say well one and all of a sudden that’s obvious but you wrote it down…nine add one equals it was a finger job counting to nine”

Table 6-11 Finger use as tools

Fingers are also tools and their use has been noted in pupils who cannot recall number facts. Geary et al (2004) found that increased use of finger counting was correlated with pupils who had weak working memories; it was also, though, correlated with more finger counting errors.

Tools though were not just seen as an aid for rapid access to number facts. They were additionally viewed as a means of establishing understanding in a speedier manner than they had observed using other methods. Staff commented on this success (Table 6-12).

Rapid success using tools	
Lisa	"she could not add two numbers together…she certainly couldn't carry…I have three lessons with her of 20 minutes…she's doing up to hundreds beginning to carry and understands…that you only have nine in each column"
Tyra	"they like the pizzas…with who has more of the pizza if someone has 6/15 or 5/16…some of them would automatically say 5/16 because 16 is bigger than 15 but actually when they see that"
Tracy	"I remembered we had the fraction walls where you could take the parts out….we did the same…with play-doh we made some shapes…look I've got half my square…then chop it into quarters…they was like *(intake of breath)*…look at all the numbers thinking I can see that one is two times that one…that's it"

Table 6-12 Rapid success using tools

Time pressure was ever present and so, for some staff, tools were a timesaving device (Table 6-13)

Tools for Timesaving	
Tracy	*On using and pre-teaching word lists* "then I'm not having to slow down and wait for everyone else in my class because they are at the same level of understanding"
Linda	"take Numicon…the children just create a solid idea in their head the red one's always going to be 5…it helps them get a bit quicker…if you had multilink…they're counting…double-checking…they know that red one is a five they can get faster…I need this five and I need a ten to make fifteen nice and easy…they're confident that's it…makes my job so much quicker"
Lou	"we were doing pattern last lesson…using multilink…he got good at predicting what was going on one end and what was at the other end got the patterns very quickly"

Table 6-13 Tools for timesaving

Here there is some indication that choosing the right tool for the objective is important as well (Chinn and Ashcroft, 2007). Multilink was praised by Lou for its facility in supporting pattern learning whereas Numicon gave a more rapid and visual representation of 10 and units in Linda's work.

6.3.1.1 Discussion

Vygotsky's argument that pupils with SEN can often benefit significantly from using psychological tools to access learning which they do not access by traditional methods (Vygotsky, 1993) is demonstrated by the interviewees' descriptions of their use. Tools are here seen as effective in supporting pupils and staff under pressure of time. First of all for some who need rapid access to number facts in order to complete more complex calculations, secondly for pupils to understand concepts more speedily and easily, and finally to save staff time to concentrate on more fulfilling activities in mathematics that promote investigation and understanding.

In the use of tools here pupils "see" and it's "obvious" (Table 6-10). The tools may be connecting with their higher psychological processes of memory by the visual-spatial sketchpad, supporting the phonological loop and working memory. What was 'tricky', Penny (Table 4-1) is now clear. These pupils now 'know' instantly through a different route than those who know by instant recall.

6.3.2 Teaching

The speed at which pupils could see a number fact, and understand a concept, when tools were used was felt to be a bonus by teachers and LSAs. They still, however, expressed concerns about the overall pace of progress expected. They felt that the pupils needed time for consolidation of their learning (Table 6-14).

Teachers' desire for pupils to consolidate learning	
Tess	"but it's time and money as usual…whether you're going for a quick fix or you're going for a long-term solution…you'd go for a long-term solution save money in the long-term…it's…preventative isn't it"
Toby	"they haven't had a chance to really consolidate it and that's what worries me"
Tyra	"some of them find it more difficult because they haven't learned the written methods yet it takes them a while to learn the process of doing the questions"

Table 6-14 Teachers' desire for consolidation time

This encompassed time to think, time to learn all the related information and time to understand (Table 6-15).

The necessity for more time	
Toby	"you still need actually *(pace to)* keep them engaged interested but you do need thinking time" "I think they might need a bit more time finding the relevance of it as well as making it clear…it will take that lesson to know what language might be used"
Tracy	"I think it's individual so a person in my class who's been on Numicon…she doesn't have speech and language difficulties she doesn't particularly have memory difficulties she just takes time really"

Table 6-15 Necessity for more time explained

6.3.3 SEN Support

Lydia was concerned that taking time to understand the conceptual underpinning of mathematics was too slow:

> "I understand the reasons why they need to do those steps first … I know they'll get there in the end but it seems to take an awful long time for it"

This may reflect her awareness of the requirements of the curriculum, or her early exposure to rote learning of facts and procedures.

Despite Lydia's concern about taking a long time to understand, several LSAs joined the teachers in their concern about the need for pupils to have time to consolidate their learning (Table 6-16).

LSAs' desire for pupils to consolidate learning	
Linda	"just finding out for themselves how it works rather than having someone going right we've talked through this all lesson and you can do it with me sat here"
Lisa	"you think to yourself if I could just go in there *(into the classroom)* and consolidate it in there"
Liz	"they get all the information…but don't have time to get to grips with it…have more time to use it and use it more consistently"
Lea	"using the number-line *(addition)* you're going up the line he's starting to get it… the teacher says we'll be doing take away…the number gets smaller we'll start at the right hand side and go under the line…the new concept hasn't been consolidated they need longer on it"

Table 6-16 LSAs' desire for consolidation time

Two LSAs also wished there was more time to spend with their pupils (Table 6-17).

LSAs' desire for more time with pupils	
Lisa	"you know if you could spend a little more time with them you could do more for them"
Lou	"he's got such an imagination and you just think if that child had that extra time to bring it out"

Table 6-17 LSAs' desire for more time with pupils

Thus, the pressure on time permeated through all the teaching and support work. Lack of time was observed to prevent pupils understanding and staff from ensuring that the learning that had taken place was firmly established for the pupils.

The teachers and support staff did not appear to choose, or agree with, this pace for their pupils with SEN and MaLD. Staff comments showed that they felt external pressure from the NC, and it is to this that I now turn.

6.3.4 Curriculum

Here there are three strands to these comments, firstly the requirement of speed of recall and efficient procedures, secondly the number of objectives to be covered at a prescribed level and finally the pressure of the SATS tests.

The key stage 2 curriculum in use at the time of the interviews required speed of recall for number facts, for example:

> *Year 6 Pupils will* "use knowledge of multiplication facts to derive quickly squares of numbers to 12x12"
>
> (DfES,2006, p.93)

And an ability to carry out procedures that are:

> "efficient, reliable, compact…for each operation" (ibid. p.67)

Finesilver (2017) points out that what is efficient for one pupil will not be the same as for another.

Secondly the teachers faced a dilemma. On the one hand the goal of meeting pupils' expected levels within the number of objectives required in the NC, on the other their commitment to teaching for understanding. The demands of the NC requirements were introduced spontaneously by most teachers (Table 6-18).

Meeting curriculum requirements	
Tess	"I'm under pressure to produce children that can hit particular things at particular times"
Trudy	"I was thinking about the year 6s and I felt it's that struggle…I've got to go way back to the very beginnings so this would be true understanding…I get this box of multilink…thinking to myself I'm in year 6 and we've got exams in however many weeks what am I doing"
Toby	"you do look…and think there's quite a few children in year 5 who came in as a 3 so classed as 3b and they're 3a in year 5 so they've only moved on 1 sub-level in that time so you automatically think oooh" "I think you've got to cover so much"

Table 6-18 Meeting curriculum requirements

The pressure to meet NC requirements resulted in teachers going against their principles and teaching to pass exams. This was particularly true of the teachers working in year 6 (Table 6-19).

Teaching for assessment results	
Tess	"I'm jumping through hoops rather than actually do what I believe is fantastic maths teaching…I'm more concerned with the four rules of number…may have a knock-on effect later if they don't necessarily understand it"
Trudy	"the whole concept is beyond where these children really are the true concept understanding … at that point you have the dilemma do I just teach these children a process to get them through the test" *Reflecting on the pupil moving to secondary school* "I'm sure that the teachers are probably swearing at us saying this child's come up as a level 4 and what they can't do"

Table 6-19 Teaching for assessment results

When KS2 SATS were nearing the pressure to meet the objectives of the curriculum was apparent with the teaching and support staff. Trudy described her "panic" when pupils reached years 5 and 6 when SATS were close (Table 6-20).

Teaching to the test	
Trudy	"in education in terms of getting children through tests there becomes this peeling back situation in (*years)* 3 and 4 and then when children get to *(years)* 5 and 6 that's when panic sets in and we have to get children through the process because we've got to jump through the hoops of the assessments""
Liz	"towards SATS time when we're taking children out more and it's just the basic things even things like multiplication and division"
Tess	"as soon as a child's got to level 3 he should stick to that one quick method teach that and then they can apply it in whatever situation… this year we're doing exam situations" "a particular child was able to have everything he needed to do within that *(exam)* …he could use decomposition … he could do multiplication using the grid method his division was still dodgy but he was sound on those three and so he hit an average which is really good"

Table 6-20 Teaching to the test

Tess argued that lack of time led to the "quick fix" solution when covering curriculum objectives. The quick fix was using rote learned procedures. The focus was on fulfilling the curriculum at a suitable level to gain acceptable grades in the KS2 SATS.

With these requirements it is no surprise that not only memorization, but speed of recall is prized and encouraged by teachers and LSAs.

6.4 Summary

In this chapter it can be seen that issues relating to time concerned the pupils. These were in their ability to keep up with the pace in class time, and the need for more thinking time. Additionally, Peter showed how anxiety can take over when work is not understood but he feels that he must complete it, but he is "not brave enough" to ask for help (Table 4-9).

The staff was also concerned about time. For them, not surprisingly, fulfilling the objectives of the curriculum was a pressure. The negative effects on pupils with SEN and MaLD are seen in their observations of pupils being moved on too quickly; pupils were left with gaps in their conceptual understanding and had not time to consolidate their learning. As they do not have all the facts and procedures in rote memory either, they are left without either alternative of conceptual understanding or rote memory available to them.

The curriculum is found to place an additional pressure on time in its demand for speed of recall, and efficient procedures. Pupils, who need thinking time, can have memory difficulties which include speed of processing. When they are unable to access a response quickly, or do not use an accepted procedure accurately because they have not fully understand the principles, they can be left with the perception that they are poor mathematicians, and/or develop mathematics anxiety.

The use of tools, here, was shown to support speed of processing, through the visual-spatial sketchpad. The pupils, instead, accessed the speed of knowing that was shown above to function as a replacement to speed of recall, through a visual "roundabout path". Tools were also shown to underpin procedural and conceptual mathematics.

In this chapter, again, we have seen the strength of the pupils' abilities to highlight their own difficulties, here in relation to time. They knew they needed more time both to complete classwork and for thinking time, this was corroborated by staff feelings and observations. The pupils' information about

themselves has added to our knowledge about the abilities of pupils to speak for themselves, and, just as importantly, to add to and/or corroborate adult impressions.

7 DISCUSSION and CONCLUSION

7.1 Introduction

The experiences, beliefs and feelings of pupils, LSAs and teachers have given a rich source of information in which to discuss mathematics education. The founding principle of this chapter is Vygotsky's statement that:

> "the child is not directly aware of his handicap. Instead he is aware of the difficulties deriving from the defect"
>
> (Vygotsky, 1987, p.309)

It is children with SEN and MaLD that remain foremost in this research, in efforts to secure improved outcomes within their mathematics education. These outcomes, for me, are as equally based in their enjoyment of the mathematics learning environment and knowing that they belong and can learn, as in their attainment.

I will discuss my findings taking the research questions in turn.

1. What are the feelings and beliefs about, and experiences of, mathematics education expressed by pupils with SEN and MaLD, their teachers and Learning Support Assistants?
2. What are the main factors shaping these beliefs, feelings and experiences?
3. What are the roles of tools in disrupting the course of these factors, and improving outcomes?

The analysis of the interviews indicated three overarching factors shaping the pupils', LSAs' and teachers' feelings, beliefs and experiences. I begin therefore with a brief résumé of the described experiences, feelings and beliefs of pupils,

LSAs and teachers which were considered in detail in chapters 4, 5 and 6 and which answer my first research question.

7.2 Research Question 1

What are the feelings and beliefs about, and experiences of, mathematics education expressed by pupils with SEN and MaLD, their teachers and Learning Support Assistants?

7.2.1 The Pupils

The pupils responded to me with humbling openness about a school subject that had negative effects on their emotions. They expressed an anxiety that was particular to mathematics, accompanied by expressions of dislike, boredom, embarrassment, sadness and anger. There was a sense of isolation, of exclusions through inclusion, in a mathematics world they didn't really feel they belonged to. One pupil presented as emphatically anxious about mathematics, stating very clearly that he didn't feel like this in other school subjects. Another pupil implied a sense of caution about mathematics, it was "tricky". How was it trying to trick her? What did she distrust? There were rare moments of pleasure for some, but none for others.

In a Vygotskian interpretation their emotional reactions and behaviour are secondary symptoms arising from the conditions in which they find themselves.

They have experienced the mathematics classroom for five to six years and have met continued low attainment. They described a classroom in which they could not follow all the teacher talk, did not always know the vocabulary and could not memorise what they were expected to memorise. Time was also significant for

several of the pupils unable to complete tasks in the time allotted and the pupils themselves were aware of needing more thinking time.

The data consisted of many negatives 'cannot', instead of 'can'. Nevertheless, there was not, yet, a lack of motivation to learn and succeed - a dream of being the "bestest at maths in the whole world".

What has been of significance in this thesis has been the pupils' ability to demonstrate and describe self-awareness of their feelings about the mathematics classroom and their place in it. These are their expressions, not an adults' representation of what they might be feeling.

Adults working with pupils with SEN work hard to build pupils' understanding of their strengths and aim to keep self-confidence and resilience high. I held no doubt that staff working with these pupils did exactly that; however, the pupils giving their own perspective have revealed how fragile this policy is in a classroom where they experience learning difficulties. The label 'mathematics anxiety' appears to me to be inadequate and has a distancing effect from the learners' individual experiences, which are varied, and which they have explained in more detail than hitherto published for this age group of pupils with SEN and MaLD.

7.2.2 The LSAs

The LSAs often gave an adults' perspective of similar negative emotions as expressed by the pupils. Most expressed feelings of helplessness, inadequacy, frustration and embarrassment. Several felt that they would never be able to improve and were unwilling to challenge their self-perceptions. LSAs were

empathetic towards the pupils' behaviour and the underlying negative feelings that they perceived.

They remembered a mathematics education of rote-learned number facts and procedures which they recalled repeating and repeating until they were ingrained. Several espoused the view that rote-learning would be the only way that pupils with SEN and MaLD would be able to progress with mathematics, possibly reflecting their own relationship with mathematics and transferring this belief to the pupils. The LSAs were aware of the pupils' difficulties with memorisation, but still held that rote-memorisation was important for number facts and procedures.

Several LSAs described the difficulties they experienced in the face of, to them, new and different approaches to mathematics learning based on conceptual understanding. For some their rote-learning had become so ingrained that they fell back on known procedures when challenged by these methods in class.

Two LSAs had developed an enjoyment of mathematics; this had grown from new understanding learned within the contemporary primary classroom, by observing the teachers and pupils. One told me that she still found herself bound by her own rote-learned methods at times but was developing an awareness of mathematical concepts and displayed self-confidence in this understanding.

All LSAs believed that there was not enough time for the pupils to learn and consolidate their learning. The LSAs felt that the curriculum was making too many demands at a speed in which the pupils they supported could not cope.

7.2.3 The Teachers

In contrast to the pupils and LSAs the teachers all enjoyed teaching mathematics, most also enjoyed learning it. The majority of teachers recalled an education of rote-learning, which did not spoil their enjoyment; this is possibly not remarkable if their memory functions were able to cope with this approach. Two, though, found this approach unpleasant and unsatisfactory.

Several teachers commented on the difference understanding had made to them when they went on to further mathematics study or to teaching the NNS curriculum (DFEE, 1999). For some, this did not just affect their understanding but also their enjoyment of mathematics, and thus their emotional well-being.

The teachers were all keen to use pedagogical methods which reinforced understanding. However, like the LSAS, they believed that memorisation of number facts and technical language was an ideal, whilst acknowledging the difficulty, even impossibility, of this for some. They also believed that this knowledge would allow pupils to move on to higher mathematics work.

The teachers recognised the general anxiety about mathematics expressed by the pupils and in behaviours they had observed. They also confirmed the pupils' descriptions of difficulties with memorisation.

Their views that the curriculum was moving at too fast a pace, owing to too many objectives to cover, endorsed the LSAs' opinions. The teachers, too, would like more time to ensure pupils had consolidated their learning, but even more importantly for the teachers, in comparison to the LSAs, to consolidate their understanding.

7.3 Research Question 2

What are the main factors shaping these beliefs, feelings and experiences?

In the responses to research question 1 we can see that teachers, LSAs and pupils held two beliefs in common. Firstly, memorisation was difficult but a fact of life in mathematics learning; secondly more time to learn was necessary. There were individual and group differences within these two beliefs; nevertheless, they stood out to me as symbolic of two factors, time and memory, that shaped these beliefs described through shared and individual experiences.

A third factor was the emotional responses to mathematics which showed stark differences between two groups of people. Those who felt they understood, and enjoyed mathematics and those who did not understand, and did not enjoy mathematics. Dowker et al. (2012) found a correlation between young children's anxiety and how well they perceived themselves to be doing in mathematics, in this data the young children's negative responses go beyond this and reveal that they know they do not understand but wish to.

To summarise, the factors that I have revealed as shaping the beliefs, feelings and experiences of the interviewees are: memory, time and emotions. Although I have written about these factors separately I note that these factors interrelate with each other in their roles and impact.

I move now to a discussion of these factors in relation to research question 2 from a Vygotskian perspective. Here I will consider the effects of natural and cultural development set in the mathematics educational environment. I discuss how a disjunct between some children's natural development and our cultural

norms mean that some children with SEN and MaLD are not able to access typical cultural paths to mathematics learning. Here sits the incongruent place (Bøttcher and Dammeyer, 2012) between the child's biological facilities and the culture she/he must develop within.

7.3.1 Historical-cultural norms

The historical-cultural influences of mathematics education appear in various guises: mathematics research, the NC, pace of progress and assessment. These have influenced the manner in which expectations about memory and time are legitimised.

Vygotsky had pointed out that the environment is already laden with the culturally conceived end points of development; pupils are receiving and working towards the expectations already established by previous generations. This end result defines not only what is to be achieved but how it is to be achieved. He spoke specifically about mathematics when he said:

> "primary forms of children's arithmetical thinking are involved in interaction with the already established arithmetical thinking of adults…the final form which should result from the whole course of child development, is already not only present, but actually determining and guiding the first steps which the child takes…"
>
> (Vygotsky, 1994b. p.348)

I will begin by discussing our cultural acceptance of memory, its forms and facilities, as one defining factor of good mathematics.

7.3.1.1 Research and Memory

In some mathematics research memory is employed as a variable, or a salient characteristic, of pupils' ability in mathematics. Geary et al. (1991) found that pupils, who they described as having mathematics disabilities (MD), had working

memory difficulties. Siegler (1988) concluded that “good students” (ibid. p.833) used retrieval of facts, among other back-up strategies, whereas “not-so-good students” (ibid.p.833) relied on fewer strategies and their retrieval of number facts was weak.

Research in this area has been useful in uncovering a link between difficulties in mathematics in the early years, and memory difficulties. However, the mathematics performance researched, and its results, are defined by a culturally accepted reliance on memory. In this research young pupils are assessed on their ability to answer addition and subtraction problems. They do well, in the researchers’ terms, when they recall quickly or use sophisticated strategies also associated with accurate retrieval. Here is an example of the Vygotskian “final form” already present in the environment, the pupils are being assessed on what has been culturally defined as ‘the way things should be done’.

Siegler (1988) hypothesised that by teaching not-so-good students the same backup strategies that good students use their attainment would improve. The outcome of this attainment is:

> “to learn the correct answer (i.e., to build distributions with strong peaks at the correct answer).”
>
> (Ibid. p.850)

In this form of research memorisation is positioned as an ideal demonstration of mathematical ability and attainment. Pupils who are not proving their mathematics ability in a culturally expected manner gain labels that presuppose disability or a lesser social position in a carefully phrased description of “not-so-good”.

This kind of description was also apparent from the teachers and LSAs when they described low attaining pupils with difficulties in memorisation as “lower ability”. It seems then that culturally we are disposed to equate mathematical ability with those that utilise fast access to memorised facts from a young age. Here I find a social construction of ability based on mathematics performance within a cultural belief about the form this performance should take.

7.3.1.2 Curriculum Objectives and Memory

I have explained how the NCs (DfES, 2006, DfE 2013) both make demands on memorisation. For primary age pupils this includes technical language, times tables, number bonds, and procedures.

This memorisation has been regarded as a necessity within successive NCs, the Cockcroft report of 1982 confirming his belief in its importance:

> **“There are certainly some things in mathematics which should be learned by heart”**
>
> (Cockcroft, 1982, p.69, bold Cockcroft’s own)

In the same sentence he pointed out that the facts and procedures to be memorised must be accompanied by understanding of the mathematics to which they are relevant. There is a danger that the two skills are conflated into a single form; that understanding is only possible once certain facts have been memorised. This might encourage the view expressed by some LSAs that facts should be learned first. There are objectives in the NC requiring memorisation that may encourage the same viewpoint.

Teachers and LSAs espoused this view that memorisation was essential whilst acknowledging the persistent difficulty some pupils displayed in this regard. Not one interviewee, adult or child questioned this belief. In direct contrast, when in practice, separating memorisation from the principle of understanding, teachers and LSAs described times when pupils, with SEN and MaLD, had understood and managed higher levels of mathematics.

The curriculum can be argued, from a Vygotskian viewpoint, to be constructing a cultural norm that memorisation and understanding are inseparable. What follows is the belief that curricular attainment is reliant on memorisation; this constructs a disabling environment for pupils who do not possess this natural facility.

7.3.1.3 Time and Memory

In relation to cultural expectations, I found two interrelating areas of mathematics attainment. The first was related to the curricular expectation of memorisation, the second to the time needed for pupils with SEN and MaLD to learn.

I pointed out in chapter 2 that pace, within curricular expectations, is measured as a level of attainment in the ability to recall number facts quickly, and to carry out remembered procedures efficiently. The teachers pointed out that pupils could become lost in a lengthy calculation if the facts were not readily recalled. This suggests to me that pupils' higher mathematical understanding and reasoning is being hindered by a focus on time, speed and memorisation.

Teachers and LSAS, who are already convinced that memorisation of certain facts is essential, now not only expect their retention and recall but need it at speed.

One aspect of this focus on speed is that pupils found it difficult to complete classwork. Here the cultural norms of memorisation of procedures and facts in order to complete work are enacted within exacting time frames which are affecting the pupils' feelings of well-being directly related to the mathematics classroom.

A second aspect is regarding vocabulary, both in the pace of the teachers' spoken language and in the time required to become familiar with new words. There is a hidden need here; one pupil, for example, was upset at being told she wasn't listening. She was certain she had listened, but she couldn't remember what she had been told. In a fast and busy classroom this pupil cannot even start the classwork if the instructions are unclear to her; she is then already trailing behind. Time here is needed to define vocabulary and ensure that instruction is followed and remembered.

For teachers and LSAs more time was wanted variously to develop understanding, and to consolidate learning of facts, procedures, vocabulary and concepts. Recommendations for mathematical support for pupils with SEN and MaLD are plentiful and, in my experience as a specialist teacher, invaluable (Chinn and Ashcroft, 2007, Elliott 2008, Bird 2009, 2011). However, to claim that these interventions do not require extra time would be disingenuous.

Time is so relevant in current educational practice that Dowker (2009) included, in her analysis of intervention programmes for pupils experiencing difficulties with

mathematics, a measure of ratio gain, in which progress measured in months is divided by the time in months that the intervention lasted. The interventions were not all intended for pupils with the lowest levels of mathematics attainment, or for pupils with SEN, however the efficiency of the intervention is seen to be important. These ratio gains seem to assume that learning takes a seamless upward curve, especially so if an intervention is to be used. It is difficult to avoid the conclusion that the child's attainment is a commodity of worth, or worthlessness, depending on her/his speed of progress.

Vygotsky had seen that pupils with SEN did not learn at the same rate as typically attaining pupils, but if time is a factor in progress and memory will these pupils be denied the interventions that may be appropriate for them? Time here can be understood to be culturally dictated to prove progress, yet all who are affected by this practice, teachers, LSAs and their pupils with SEN and MaLD, state clearly that more time is needed.

7.3.1.4 Assessment and Memory

Here there are two areas of assessment that define our cultural norms. First is the mathematics SATS tests which are, currently, the defining evidence of 4 years of mathematics study in primary education. Second is the outcome of assessment for access to these exams by pupils with SEN.

I have shown how the pupils' and staff evidence in my data concurs with research which finds that teaching to the test, test anxiety and reduced performance owing to the latter are features for many within mathematics education (West, 2010, Chinn, 2008, Maloney et al. 2013).

Examinations are set on the premise that pupils must demonstrate what they know, and by corollary what the teachers have taught, and how well they have taught. The cultural principles of memorisation, as proof of mathematics learning and ability, remain in evidence in exams now set in the current NC (DfE, 2013). This replaced the NC (DfES, 2006) in use at the time of the interviews. The 2018, KS2 mathematics SATS paper 1, for arithmetic (Standards and Testing Agency, 2018a) allows no calculators and requires the pupils to demonstrate increasingly complex calculations and procedures from column addition requiring regrouping in question one, to long division in question thirty-six. The pupils are specifically told that they may be given marks for the use of formal procedures in long division and long multiplication. In addition, pupils in year 4 (age 8 to 9 years), from 2020, will take a mathematics times tables test, to ensure that they have memorised all the tables up to and including the 12 times table (DfE, 2018b).

The cultural expectation of memorisation is loaded by the need to recall at speed. The arithmetic paper has 36 questions to answer in 30 minutes, highest attainment therefore expects some questions to be solved in less than a minute. The times table online assessment gives 6 seconds to respond to each question, ensuring the pupils:

> "demonstrate their recall of multiplication tables, whilst limiting pupils' ability to work out answers to the questions"
>
> (Standards and Testing Agency, 2018b, p.8)

Are we now retreating from teaching for the understanding that theoreticians and practitioners advise? The pupils I interviewed were one and two years older than the pupils to be tested here. Despite support and aid in memorisation they

were still unable to achieve this target. Does this make them bad mathematicians? According to cultural construction it appears so.

The second area of assessment applicable to accepted cultural norms of memorisation is based within the access arrangements for exams available for pupils with SEN in KS2. There is an acceptance that slow processing will affect pupil outcomes and therefore additional time is allowed if proof is available in the form of standardised test results, assessed by an acceptably qualified practitioner. However, alternative memory functions, which may be strengths, are not accepted for consideration. In mathematics tests no "number apparatus, counters or number squares" can be used (Standards and Testing Agency, 2018c, p. 30). I assume that these are considered to give "the pupil an unfair advantage" (Ibid. p.22). I question whether this is an unfair advantage when memory can be shown, and seen, to be a natural difficulty for a child.

Here again is a clear indication that memorisation is a favoured and valued activity in mathematics, in this case favoured over tool use.

Taken together my results have shown that memorisation and recall, preferably fast, together with progress at a culturally defined pace, permeate our expectations around mathematics learning and competency. These cultural norms are revealed in some researchers' foci, in curriculum objectives, and in curriculum assessment and access arrangements. Memorisation is placed within the cultural DNA of the mathematics environment, the environment in which pupils with SEN and MaLD, who wish to understand and succeed at mathematics, are placed.

In ironic contrast, the educational community's acceptance of memory difficulties is implicit in our understanding of memory functions, the use of psychometric measurement in assessment reports and the persistent difficulties of some pupils to memorise.

One result of this is seen in the negative emotions and behaviours testified to by the pupils, LSAs and teachers. These behaviours can result in lifelong antipathy to mathematics, as one of the LSAs described experiencing. The cultural acceptance of current mathematics educational principles can disable learners with SEN and MaLD whose natural development does not facilitate memorisation, recall, and working at pace. Additionally, the mediating effects of language are not always available to these same students. It is therefore an imperative for me to look at question 3 through the same Vygotskian lens.

7.4 Research Question 3

What is the role of tools in disrupting the course of these factors, and contributing to more successful outcomes?

7.4.1 Use of Tools

There are two sets of tools that I shall write about in relation to this question. The first is the set of tools which can be regarded as "special pedagogical…devices" (Vygotsky, 1993, p. 83) which give pupils with SEN and MaLD "roundabout paths of development" (ibid. p.131).

The second set belongs to the arena of assessment. The assessment techniques that can be used to inform testing authorities, teaching and support staff, and

peers that a child with SEN and MaLD can successfully follow a different "developmental path" (ibid. p.169).

7.4.1.1 Tools in the Classroom

It was seen in chapters 4, 5 and 6 that the use of tools had positive effects. LSAs liked and some LSAs "loved", using tools. The LSAs' positive feelings about tool use were a strong contrast to their mostly negative views about mathematics. It was a source of well-being for some who spoke of their avoidance and difficulties with mathematics topics and the subject in general. Hypotheses could be developed as to the reasons for this; pleasure in seeing pupils' growing confidence and understanding, a method of learning that suited their own styles or a means of supporting the subject that supported memory and abstract language concepts. This suggests further possible areas of research.

LSAs also observed the well-being that tool use promoted in their pupils. This was confirmed by the number of pupils who requested more tools as one of their three wishes. Some pupils would have liked to use them more often, others all the time. Teachers also listed more tools as one of their favoured three wishes.

The teachers' praise of tool use was mainly focussed on its capacity to support pupils' understanding and independence. Examples of these effects were available from teachers, LSAs and pupils. The visual and kinetic nature of tools was regularly mentioned as a feature when these examples were being given. This suggests that the tools formed a link with the visuo-spatial sketchpad (Baddeley, 1997), giving an alternative route to conceptualising mathematical structures in the abstract.

With the aid of tools pupils can utilise their natural facility of perception through the sensori-motor functions of sight and touch (Gathercole and Baddeley 1990a and b, Baddeley, 1997). Here I frame thoughts about mathematics learning through Vygotsky's theory of the natural and cultural lines of development; sight and touch can serve to complement, or even substitute, the auditory to enhance higher psychological processes using cultural artefacts.

A further benefit of tool use was seen in its ability to support, or even substitute, the processes of memorisation and recall in pupils who had tried and failed for years to learn such facts as the number bonds to 10 and multiplication tables. The use of the verb "see" was common in the staff discourse about tools and memory, here 'see' can be taken literally. Again, a different channel of perception to memory was being used, through the visuo-spatial sketchpad.

Recall is a facility described as "a search for points that have been established" (Vygotsky, 1987, p.309), whereas, it seems, that in many forms of assessing mathematical attainment discussed above, a position is adopted which implies that the process of recall is only legitimate through auditory channels. Taking a Vygotskian view, I argue that pupils using either of the visuo-spatial or phonological channels have these same established points because they can give suitable responses to the same questions.

There was also evidence in the interviews that tool use could aid speed of recall; pupils could see instantly; they could calculate quickly. Here the skill that the pupils developed was in the rapid use of tools, knowing how to apply them to recall the facts. Thus, some children with SEN and MaLD are demonstrating that

they can appropriate, and deliberately control, their use of “special pedagogical tools” to master “common cultural forms” (Vygotsky, 1993, p.45).

Vygotsky (1978) pointed out that the use of tools presupposed the facility to use language as a mediating facility when children are solving harder tasks. In chapter 2 I explained how for some children with SEN and MaLD, the development of language could be a difficulty in its own right (DLD) or could co-occur with memory difficulties (Butterworth and Kovas, 2013). Some teachers spoke about the use of tools in relation to supporting language with vocabulary definition posters, and the special pedagogical method of pre-teaching vocabulary. The symbol and vocabulary support of Widget (2000), used for interviews in this thesis, is another example of a language support tool. It is not the purpose of this thesis to list all the tools used in speech and language therapy and specialist teaching that may enhance this aspect of mediation between the natural and cultural lines of development, but it is worth noting here that the pupil’s responses suggest that this is an area where mathematics education can also be enhanced with the use of tools. The memory book praised by one pupil in the interviews is likely to be serving such a function.

It can also be noted that tools were used to mediate in the place of language to support understanding of abstract concepts, for instance the distance between two numbers being demonstrated by Trudy’s use of sellotape, and the placement of one Numicon number shape on top of another.

Here we can see the benefits of tool use in well-being, understanding and recall, including, for some, under pressure of time. It is a “roundabout path to

development" that can disrupt the course of socially disabling factors in mathematics education and improve outcomes.

I will now turn my attention to that of assessment techniques, and how these tools also have contributions to offer.

7.4.1.2 Assessment

In this thesis assessment has been viewed from two standpoints, one of statutory government assessment, in the form of SATS tests, and the second in the classroom. Both forms of assessment hold the possibility of disrupting the negative effects of memory, time and emotions so here I will speak in the conditional tense, of what could be.

The curriculum has been shown to expect memorisation of number facts and language; this is nowhere more starkly evident than in the multiplication table tests for 8-9-year-olds, where derivation of facts is deliberately discouraged in favour of speed (DfE, 2018b). The implication here is that a good mathematician is being defined as a good memoriser. I argue that the equivalent in literacy could be the child 'barking at print', a phrase in common use for children who read well but do not comprehend the substance. It is known as hyperlexia and requires substantial targeted intervention to repair the difficulty. I argue that time spent on understanding the concept of multiplication, its application and methods of calculation may be more appropriate to support the teachers' view of a good mathematics education. I also argue that assessment without time limit could allow the anxious, and poor memorisers, to work and prove their knowledge at their own pace. Tools have been shown to provide support for memorisation, and

in some cases, substitute for number facts recall. Proof of understanding the use of a times table square, a number-line or Numicon, could disrupt potential failure and anxiety here.

One LSA spoke of trying to train a child, repeatedly, to memorise the number bonds to 10, an important attribute if children are to be assessed at speed. She said:

> "it gets that perhaps your time is not utilised to the best effect … she cannot retain the information she needs to go forward"

The pupil knew the number bonds when she used the tools, it seems that the pupil's as well as the LSAs' time is being wasted, and opportunities for development and progress are being lost when we focus excessive attention on a facility that the pupil does not naturally possess. A Vygotskian approach would see the use of tools in assessment to be the means of finding out what the pupil understands rather than what he/she has remembered. The assessment can then be viewed as a tool that is truly assessing mathematical ability and understanding.

In the classroom, the tool of assessment could then be used to assess what the child has not yet understood; and why this is so, rather than a blunt instrument (such as the APP grid) listing what has and has not yet been achieved. This latter type of assessment can be likened to Vygotsky's (1993) description of a list of symptoms being meaningless except in defining themselves, rather like a dog chasing its own tail. If the child's failures are not analysed cause and effect cannot be established, indeed would there even be a problem if tools were in use?

Gifford (2005) made the point that we must ensure there is no assumption of mathematical difficulties without understanding the life experiences of the child, I would here add 'without understanding the memory functions of the child'. Care in outlining cause and effect structures are important so that children are not perceived to have SEN, or MaLD, mistakenly (Gifford 2005). Gaining the views of the child is important here, and my data has proved that this is possible to do in useful detail.

Using dynamic assessment (Vygotsky, 1993) and a focus on what the pupil can achieve with the tools compared to achievement without, teachers and LSAs are well placed to demonstrate the value of their use. This form of assessment can be less intrusive than the standardised tests used in traditional diagnosis.

The Vygotskian assessment of environment is also of use here; children trying to cope in a cultural environment in which their biological development makes access to typical cultural devices and methods difficult, will slow, or even halt, their development. Teachers and LSAs described awareness of this and used the tools they had to try and combat these effects. Permission to use such tools in formal assessments would allow their teachers to focus on conceptual understanding of mathematics. To combat arguments that that this would lead to unfair advantages for learners with SEN, perhaps what is necessary is a revisioning of the current paradigms for assessment and the creation of tests in which all who sit them could choose amongst a carefully selected set of tools.

A child who has persistently failed to memorise facts can be recognised by teachers and LSAs. They are well placed to acknowledge this difficulty in

consultation with the child. In my interview research I have demonstrated that the staff and pupils can identify memory difficulties and put pedagogical practices in place to alter the path of their development. However, acceptance of these practices would require some cultural changes of attitude towards mathematics and mathematics education. Currently, assessments seem to unfairly disadvantage learners with SEN; I would suggest that the construction of assessments which would remove rather than have built in barriers to attainment is an area ripe for research.

7.5 Conclusions

7.5.1 Conclusions linked to literature review

The findings in these interviews support elements of what is already shown in the literature review and aspects of the empirical data can be linked to the Vygotskian view presented in Chapter 2. Vygotsky argued (1993) that having SEN can be isolating and excluding, pupils and staff described these feelings (Table 4-11,Table 4-12). He also stated that negative emotional experiences can be linked to the environment in terms of access to learning and cultural expectations (Vygotsky 1993, 1994a and b). Pupils and staff described the deleterious effects of curricular and memory and pace demands, both emotionally and in attainment levels, for instance: Table 5-1, Table 5-2, Table 5-7, Table 5-15, Table 6-1, Table 6-4, Table 6-7, Table 6-8.

Vygotsky also argued that memory, a natural development, and language, a sign that requires memory, were important for children to learn but that this facility was not possessed by all in equal quantities. The pupils and some staff in this

study have made it clear that for them this is the case (Table 5-2, Table 5-7, Table 5-16).

More recent research has focussed on the facility of number sense and mathematics language, (for example. Geary et al., 2000, Pimperton and Nation, 2010 and Riccomini et al. 2015). Again, staff and pupils have confirmed difficulties in these areas, especially when mathematics has been presented in an auditory and/or symbolic form (Table 5-15, Table 5-16, Table 5-26). Recent research has also focussed on the inception, presence and sometimes lifelong effects of mathematics anxiety (Dowker et al., 2012, Rodd, 2006, Turner et al., 2002). Lea is an example an individual with a lifelong aversion to mathematics, and the pupils' anxiety is particularly evident when they described their strong negative feelings (Table 4-1, Table 4-2).

Some mathematics educators have suggested that tool use is a valuable "roundabout" (Vygotsky, 1993, p.131) method for teaching mathematics for understanding (Gifford and Rockcliffe 2012, Elliott, 2008, Chinn and Ashcroft, 2007). Pupils and staff agree with this view (Table 5-19, Table 5-20, Table 5-22)

This study has added to the discourse by suggesting that pupils' natural development and the environment (comprising of curricular and government expectations, attitudes to and use of tools, and beliefs about what makes a good mathematician) combine holistically to create mathematical difficulties and reduced access to mathematical understanding and attainment.

The literature I have found relating to memory difficulties has been quantitative research, here I add the voices of pupils and staff who have experienced and

observed these difficulties. Equally, the literature I have found relating to mathematics anxiety often, although not always, tends to focus on older students. Dowker (2012) and Chinn (2009) researched attitudes of younger children but took a quantitative approach. My qualitative approach has allowed a more nuanced expression of the views and beliefs of young pupils with SEN and MaLD on their anxieties, difficulties and needs in relation to learning mathematics.

I will now look at my results to challenge thoughts about mathematics learning and teaching for pupils with SEN and MaLD.

7.5.2 Conclusions arising from data analysis

I set these conclusions in the space where the incongruence between natural and cultural development collides. It is a collision that places children with SEN into a socially constructed 'cannot', instead of 'can' relationship with mathematics. It is not a position of choice or aspiration by these young people. They want to progress and understand but a mathematics difficulty/disability has been constructed for them in the cultural expectations we place on them.

The cultural expectations found in my data refer predominantly to memory and time. Memory is accepted as an unquestioned mathematical skill in a variety of settings; in some research, in teaching, in the curriculum, in the setting of exams and in access arrangements to these exams. Rote-memorisation, understood by many practitioners and teachers to be an unacceptable substitute for understanding, is considered by most LSAs in my data as the only way for pupils with SEN and MaLD to make progress. The new mathematics multiplication table

tests for 8-9-year-olds demonstrate that this attitude is creeping into government policy, aimed at all children, but placing children with SEN and MaLD in the same net (DfE, 2018b).

This same culture has deemed what suitable, typical progress looks like. The progress boundaries change with subsequent curricula; nevertheless, what is written must always be accepted as correct. Teachers and schools are judged on their ability to ensure most pupils meet these progress targets.

The progress of pupils with SEN and MaLD is, additionally, put under scrutiny in interventions sometimes judged on ratio gain. Pupils must progress in prescribed numbers of weeks or months at a rate that proves accelerated progress. It has not been proved that this type of progress is suitable, or regularly and predictably achievable, as a measure for pupils with SEN or MaLD.

Time features heavily, not solely as a progress marker. Within the curriculum, and requirements of proof of progress, a pace of learning is set for the length of each key stage curriculum. Not only is time regulated by the mathematics learning objectives to be covered, but the objectives themselves regulate time regarding speed of recall and efficient procedural work. The testing of mathematical ability is confined to time limits as well.

Do these expectations on memory and time suit all pupils with SEN and MaLD? Pupils with SEN can be characterised in a Vygotskian perspective as having differences in their natural or biological facilities. One of these facilities could be memory. Contemporary research can account for several functions within this facility, all or some of which may be affected in the natural line of development in

different individuals. These functions include long and short-term memories in both the visuo-spatial and phonological loops and working memory. These functions can be affected by the placement of information in memory, the retention of that information and/or its recall. It has been seen in these data that most pupils with SEN and MaLD complained of memory difficulties, and that memorisation practise did not help them. Teachers and LSAs corroborated these statements.

The difficulties and failures that pupils experienced in mathematics and memorisation was aligned with descriptions of their being of “low ability”, Vygotsky does not equate any loss or diminution of a natural facility with a measure of intelligence instead he sees this difference as a feature that must be compensated for by specially designed cultural means. This is in order that such children with differences in their natural development have different routes to the same culture as their typically attaining peers. Giving these different routes could allow pupils with SEN and MaLD to concentrate on the cultural improvement of their higher psychological processes such as logical memory, verbal reasoning and deliberate attention.

A Vygotskian framework thus would offer a socially managed solution to a culturally created problem. It has been seen that Vygotskian special pedagogical devices and methods of assessment can offer “roundabout paths of development” for these children.

The pupils in my data responded well to the use of tools in aiding understanding and bypassing the necessity for recall. Tools can be seen as a liberating device

from the psychological process of memorisation. Instead of, in the words of several staff doing “it to death”, and still forgetting, pupils are able get on with accessing more of the mathematics curriculum, subsequent higher psychological processes and improved enjoyment and well-being within a fascinating school subject.

Secondary difficulties can arise from these mathematical difficulties in the form of emotional reactions and isolation from society. Anxiety and avoidance strategies, together with mixed, but always negative emotions were described and experienced by pupils, and many LSAs. These can be deemed to have developed as a result of their difficulties in learning mathematics using traditional methods. The long-term nature of these feelings was demonstrated in some of the LSAs’ comments about themselves in relation to mathematics. Those adults, who described their early educational experiences as negative, but now enjoyed mathematics, ascribed the change to their understanding of mathematical concepts and procedures. Most of those that described lack of confidence in mathematics recalled a rote-memorised mathematical education.

Mathematics practitioners have created tools that have changed LSAs’ and pupils’ perspectives on mathematics. Increased well-being was experienced by the LSAs with the use of tools. The pupils equally liked using the tools, and their increased well-being was observed by staff. It seems a contradictory environment when “roundabout paths” are developed successfully, only to be removed at times of great stress.

From the above I argue that cultural norms will have to be revised in order that the social management of difficulties in learning mathematics can be addressed.

The following recommendations I consider important, not least because the evening before I wrote this section, I first met a new pupil, a 9-year-old with diagnosed dyslexia. She sat with me in tears, telling me how she "hated maths", was embarrassed that she needed her fingers to count on, that she couldn't recall times tables and didn't always know the words that were being used. It was distressing to meet such a young person feeling so negative about her experiences. Her new mathematics story last night began with a bag of tools to play with, with her mother, and to investigate following guidance from our first lesson. I keep her, and the interviewees, in mind as I make the following recommendations.

7.6 Recommendations

Firstly, we should revisit the assumption that memorisation, speed and being good mathematicians are irrevocably linked. The expectation in mathematics education that memorisation, recall and working at speed are desirable attributes, worthy of higher marks in assessments has a ring of Cartesian duality rather than the unity of Vygotskian dialectics. Memorisation is, of course, acceptable, for those for whom it is a natural facility that develops, and is enhanced by, understanding. Memorisation through either or both of the visuo-spatial sketch pad and the phonological loop can be, and often are, acceptable methods of learning. However, those pupils for whom the natural facility of memory makes retention and/or recall difficult or impossible should be allowed

the “roundabout”, physical, tools that enable them to work within their higher psychological processes.

Therefore, I recommend that mathematics education recognises the use of tools as a substitute for recall and speed of recall. They should be available in exams. In this way we will ensure that learners with SEN and MaLD are not put at an unfair disadvantage, as opposed to the current implication of “unfair advantage” (Standards and Testing Agency, 2018c, p. 22).

Mathematics tests should also have the elements of time, speed and efficiency[6], removed. To do something as well as possible requires time and revision, the writer of this thesis recognises this only too well. Pupils with SEN and MaLD should be allowed the time to explore their understanding and show what they can do without the artificially and culturally conceived pressures of time.

Arranging access to exams need not be any more onerous than they are now. My recommendation would be to allow pupils to work in mathematics exams using the methods that are usual for her/him. This type of access already pertains to the use of word processors. Teachers, LSAs and pupils can identify memory needs in relation to this, as seen in my data. Should a more formal position be taken, which I do not consider necessary, there are standardised memory assessments available that can prove need (pp. 80-81), as is the case with accessing a reader or extra time.

By allowing these adjustments we would be working more closely with the legal definition of equality enshrined in the Equality Act 2010. We would be ensuring

[6] Efficiency here defined as in Finesilver, 2017, in the use of short-cut, practised and recognised algorithms

that mathematics tests were not testing the wrong things, memory instead of mathematical understanding. We would be ridding some young children of one source of mathematics anxiety, the need for memory and speed in tests. Finally, we would be allowing teachers to do what their experiences, beliefs and feelings have told me in the data, teach for understanding.

Teaching for understanding can be made more readily achievable. A change in culture from the examination system can lead to changes in some of the objectives in the NC. For instance, I recommend that 'efficient' procedures give way to methods that demonstrate understanding of the concept, proof of access to number facts substituted for 'rapid recall', and methods of access to the vocabulary for knowing the vocabulary.

As the culture from government directives and expectations changes my recommendations for school practice would have even more grounds to be implemented. All the interviewees recognised the anxiety that a mathematics education can inculcate. The first aim then is to reduce, if not expel this anxiety. Tools were shown to increase well-being in my data. Tools should always be available in lessons on mathematics, and mathematical elements of other subjects.

This will require investment in such tools for all schools, staff training in their uses for teachers as well as LSAs, and a commitment of time to teaching the pupils how and when to use them. This new cultural approach would also require sharing with parents/carers.

Staff in my data stated that whole class use would reduce the tools' connotations of belonging to pupils of "low ability". This label I deem to be absurd when it is the reduction of a natural function that the label is based on. "Special needish and babyish" was also mentioned in relation to tools. A wider implication therefore is in the training of staff and children in the different ways that memory can operate, that one route into memory is as acceptable as another, in terms of education this belongs to themes of social acceptance and a commitment to diversity.

With the success, reported in my data, that pupils with SEN and MaLD find with the use of special pedagogical tools I suggest that we are, to use a Lilliputian metaphor, cracking the wrong end of the egg, in our aspirations and expectations for them. Does meeting the needs of pupils with SEN mean that we must expect increased attainment in tasks that demand a load on a form of memory that is not available to them? Should we instead be considering the meeting of needs in access to mathematics through a reconsideration of what is important in a mathematics education? The use of special pedagogical devices and methods enable some pupils with SEN and MaLD to explore mathematics with interest, confidence and understanding. The NC, exams and the school environment could be changed to accommodate these recommendations and therefore I offer these recommendations with the support of my data.

7.6.1 Limitations of research

These data came from one school, in one month, therefore the limitations can be found in the small-scale nature of this research, and the small number of interview participants. The limitations of this small-scale research reside in the

limited number of voices that have been heard and the fact that the cultural setting of just one school was investigated. This could have skewed the data, not only because the school will have its own values influenced by leadership and staff appointment decisions, but also because other voices within the school, or other schools may have given entirely different opinions.

The thesis is also limited by my own background, research interest and research lens. However, this research approach can be readily replicated, and readers may recognise some of the findings inherent in this thesis. Some of the findings were indeed replicated from my IFS (Bauer, 2013), in this the staff: LSAs and teachers, felt that the rapid pace and demands of the curriculum were not supportive of the needs of their pupils, and that this contributed to the strongly negative feelings of anxiety and inadequacy about mathematics in the pupils. Similarly just two members of staff recalled learning mathematics with pleasure and most LSAs still felt anxious and inadequate in their understanding of mathematics and their support roles. Only one teacher in the secondary setting used tools in the mathematics classroom, the others deemed them to be belittling for this age group, the pupils strongly disagreed. The LSAs would have liked training in tool use and to see them readily available for the pupils.

7.7 Methodological implications of this study

The tools I created for the interviews with the pupils proved successful in eliciting nuanced responses from children with SEN. They were straightforward to create, and the pupils enjoyed using them. They took pleasure in exploring their thoughts by opening successive envelopes, using the cards and deciding the course of the

interviews. This method could benefit future research when interviewing such young children.

Education has the potential to expand life chances for all young pupils and older students, including those who are currently disadvantaged by their line of natural development. The young people I interviewed, who gave their thoughts and time so generously, are keen to do well but find that the cultural line of development does not readily support their needs in the mathematics classroom. Their teachers and LSAs were keen to do as well as they could for these young pupils in a culture of expectations that makes many other demands on their work. In an inclusive society we must to strive to ensure that the "roundabout paths of development", and "special pedagogical techniques, devices and methods" (Vygotsky, 1993, pp.131 and p.83) are made available, and kept updated, to meet our current knowledge of SEN in order that these pupils can enjoy their mathematics education, feel included and that mathematics understanding and attainment is a distinct possibility for them.

7.8 Future Considerations and Research

This work has added to our knowledge of the beliefs and feelings of primary school pupils with SEN and MaLD about their mathematics learning. It adds to Dowker et al. (2012) who found that these pupils considered themselves to be poor learners. The pupils here showed that they wanted to learn but that the pace of learning, lack of understanding and difficulties with memory and language added to their anxieties. These statements by the pupils were confirmed by the observations of adults working with them.

Tool use was found to be a valuable access resource that was not available in all situations that these pupils would find useful. An investigation of tool use as a constant source in every mathematics setting: learning, practice, and examination, as a means of increasing well-being, understanding and attainment, could be instigated.

I also suggest research into the development of formal assessment methods of attainment that do not place pupils with SEN at a disadvantage because they are not born with the biological facility of a strong memory. This could include investigations of student performance without time-limited constraints and the provision of tools that enhance memory. The results may lead to a re-evaluation of the definition of a good mathematician. They could also lead to policy research into whether lack of access to tools and expectations of neuro-typical methods of working, relying on speed and memory, is a disabling position and incompatible with the Equality Act (2010).

Another strand of research could focus on LSAs' feelings and personal mathematical development in relation to school support and tool use.

Finally this research could be scaled–up in terms of interviews with pupils using the methodology of card use. I have reported some of the uses, and some adjustments that may be necessary to card use (pp. 110-115), this itself could constitute more research. The cards have been shown to nuance the expressions, thoughts and feelings of the pupils interviewed; this was not the focus of analysis in this thesis but opens the methodology for further uses.

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Appendices

Appendix 1 Letter to Gatekeeper

Research Ethics Committee Number: SSHL/13/14-23

KING'S College LONDON

Dear .....,

Research study title: An environment for maths learning: what factors improve the teaching of maths to pupils with maths learning disabilities.

I am asking for formal permission to carry out this part of my doctoral research, as a student Education Doctorate researcher at King's College, London, at ..... Junior School, during this academic year 2013 -2014. The study has been approved by King's College London Social Sciences, Humanities and Law Research Ethics Subcommittee.

I have included a copy of the information letters for staff, parents and pupils and have already gained ethical permission from the ethics committee at King's College, London. I have set up steps to ensure that all participants will be safeguarded.

I would hope that the research will benefit the school by engendering a report on what is in place and any training that may support further improvement, if appropriate. This could have implications for future action research to improve teaching, learning and results for the cohort of pupils with SEN and should have broader relevance to schools and maths departments with similar backgrounds to your own.

If you are happy to give permission I would be grateful for an e-mail or letter to confirm this.

Thanking you,

Yours sincerely,

(Ann Bauer)

Email: ann.bauer@kcl.ac.uk

Address:

Telephone:

Appendix 2 Letter of information to staff for information evening

Research Ethics Committee Reference Number: SSHL/14/14-23

Education Department

c/o

Education Department

Waterloo Bridge Wing,

Stamford Street,

LONDON SE1 9NH

Dear .....,

I am writing to you about my research into teaching maths to pupils who have maths learning disabilities. It is known nationally that pupils who are struggling with maths at the end of key stage 2 are less likely to have made expected progress by the end of KS4.

Your school has put a lot of effort into improving results in all subjects across age groups and ability levels. In this part of my research I want to investigate what is in place in maths and whether there are any strategies that could add to an understanding of approaches that make the teaching of the SEN cohort of pupils more successful.

In this letter I am writing as a student researcher at King's College, London. I would like to invite you to a meeting **on ....., at ....., in .....** to explain more about my research and request that you might consider participating in this research by taking part in a 1:1 interview of approximately 30 minutes length at a later date. The study has been approved by King's College London Social Sciences, Humanities and Law Research Ethics Subcommittee.

It is important to me that you know that attending the meeting and/or agreeing to participate in research is not compulsory. Your choices will have no impact on your career within the school, indeed confidentiality is so important that I won't be informing anyone about who is participating. You will not be asked to state at the meeting whether you will be willing to participate; instead I will be giving you more information about the research and how it will be carried out.

I look forward to explaining more about the research and hope that you are able to attend.

Thank you very much,

Yours,

Ann Bauer (student researcher at King's College, London)

Appendix 3 Letter of invitation to parents for information meeting

Research Ethics Committee Reference Number: SSHL/13/14-23

Education Department

c/o

Waterloo Bridge Wing,

Stamford Street,

LONDON SE1 9NH

Dear Parents/carers

I am a research student at King's College, London. I am researching for an Education Doctorate into the teaching of maths to pupils with special educational needs who find maths difficult. I am studying how maths learning and teaching can be improved to help our pupils with SEN.

I am writing to you as a research student because I would like to ask for your permission to interview your son/daughter as part of this research. I don't want you to give permission now but I would like to ask if you would attend a meeting on**....., at ....., in.....** to find out more about the research, and how I would protect your son/daughter throughout the study.

The study has been approved by King's College London Social Sciences, Humanities and Law Research Ethics Subcommittee.

I must stress that attending the meeting does not mean that you have to agree to your son/daughter taking part in an interview. You do not have to attend the meeting or agree to your child being interviewed.

If you can come to the meeting, or are interested in finding out more but the date and time I have given you is not suitable, please would you fill in the form attached and return to the reception desk at school.

If you agree to ..... name ..... taking part in an interview and you do not wish to attend a meeting or need more information there is a section on the next page for you to tell me this. I will then post the consent form to you for signing.

Thank you for taking the time to read this.

Yours faithfully,

(Ann Bauer)

For the attention of Ann Bauer

Please delete as appropriate:

Name.....

Child's name .....

Telephone number .....

I am able/unable to attend the meeting on..... at..... in .....

I would like/would not like another time to speak with you

If you are able to meet at another time please complete below:

I am able to speak with you before school/ during the morning/ during the afternoon/ after school

or: I am happy for you to approach ....name..... about taking part in an interview and I do not wish to attend a meeting

Please leave this form at reception in school, or use the stamped addressed envelope for posting

Thank you for your time

Appendix 4 Letter of invitation to pupils for information meeting

Research Ethics Committee Reference Number: SSHL/13/14/-23

Education Department

c/o Chris Abbott,

Waterloo Bridge Wing,

Stamford Street,

LONDON SE1 9NH

Dear ....Name.....,

Your mum/ dad/ carer's name has told you that I am studying at King's college in London. I am studying different ways of teaching and learning maths. Some ways of learning maths can make maths easier; some ways can make it harder.

I have met with your .....name already because you are not yet 16 years old. I had to ask him/her/them if I could speak to you about my study. Name has said yes.

I would like to meet with you to tell you more about my study. My study has been passed by King's College London Research Ethics Subcommittee.

In the meeting I will also ask you to think about talking with me about your maths learning. It will help me to find out what pupils think. I won't talk to you about your maths learning at this meeting.

You don't have to meet with me. If you do meet with me you don't have to agree to have another talk with me about maths. If you would like to meet with me, please will you fill in the form and hand it in to the school reception.

Thank you for reading this.

Yours sincerely

(Mrs Bauer)

Appendix 4 Continued

Please return completed form to school reception:

Name.....

Class .....

I **will/will not** meet with you to hear about your study

If you agree to meet please choose one of the following:

1. I would like to meet in a group with other pupils who have been asked to help
2. I would like to meet with you on my own
3. I would like to meet with you and my mum/dad/carer/support assistant

Signed ..... **Date** .....

Appendix 5 Information sheet for staff and parents

INFORMATION SHEET FOR PARTICIPANTS

REC Reference Number: SSHL/13/14-23

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

TITLE OF STUDY

An environment for maths learning: what factors improve the teaching of maths to pupils with maths learning disabilities.

I would like to invite you take part in this research study. The study has been approved by King's College London Social Sciences, Humanities and Law Research Ethics Committee. Before you decide whether you want to take part it is important to know why the research is being carried out and what your participation will involve.

Please take time to read the following information and discuss it with others if you wish. Ask me if there is anything that is not clear to you or if you would like more information.

You should only take part if you want to; choosing not to take part will not disadvantage you in any way. If you decide to take part you are still free to withdraw at any time and without giving any reason

If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form.

What is the purpose of this study?

The aim of the study is to find out whether existing methods of teaching maths, and the guidance and policy on maths teaching within England, are sufficient to improve the attainment of pupils with SEN. I wish to find out your views as part of my research for an Education Doctorate..

Aims:

The aims of this part of the research are:

i. to find out about current methods of teaching maths to pupils with special educational needs (SEN) who are struggling with maths

ii. To find out what teachers', support staff' and pupils' opinions are on current methods of improving outcomes in maths

iii. To find out what teachers, support staff and pupils believe to be strengths and weaknesses of the current system of teaching maths

iv. To investigate maths target setting for pupils with SEN

v. To find out what teachers, support staff and pupils would like to have available to support the teaching of maths to pupils with special educational needs.

Possible benefits

i. There will be a meeting and report to summarise the main findings

ii. Joint work with researcher and school including discussions as to the way forward for the teaching of maths to pupils with SEN who have specified difficulties with maths, and training sessions from the researcher, if considered appropriate, for learning support staff and maths teachers.

Participants

Your school is a focus of this study as it is a school with a high proportion of pupils with SEN. The school has a proven track record in aiming to raise maths attainment for all pupils and your experiences put us in a good position to present information that could also apply to other schools in similar circumstances. Your own experiences will give useful insight into teaching and supporting maths, and improving maths attainment for pupils with SEN

What will happen if I agree to take part?

If you agree to take part you will have an interview with me for approximately 30 minutes. The interview will be held 1:1 in a private space within our school or at another space, away from the school, deemed suitable by both of us. The interviews will be audio-recorded.

The interviews will follow a semi-structured interview pattern and will take no longer than 60 minutes. There may be an occasion when I request another meeting if I need to clarify my understanding of anything you have said in the interview

You will be given a pseudonym after the interview. Interviews will be recorded, subject to your permission. Recordings of interviews will be deleted upon transcription. In the final presentation of results your own words may be used in text form. This will be anonymised by pseudonym so that you cannot be identified by what you have said.

You can withdraw yourself from the study at any time, you may also withdraw any information you have already provided until two weeks after the interview.

You can withdraw from the study by informing me, Ann Bauer, without giving any reason for withdrawal.

Are there any risks?

I am very keen to gain your true perspectives so I am being very careful to protect your confidentiality, please look at the confidentiality section below.

If you become at all uncomfortable in the interview you are free to refuse to answer any questions, and to withdraw from the study at any time without giving a reason. You will be speaking with me in the position of a student researcher at King's College, London and as such your participation and/or withdrawal will not affect your career within the school.

Confidentiality

This is a very important aspect of your participation and I would ask you to read this carefully.

- You will be assigned pseudonyms in the transcription and write up of the interview data
- Within the write up of the interviews you will not be able to be identified by your job description. All learning support staff will be known as learning support assistants
- There will be no sharing of interview data except with my research supervisors at King's College, London
- Local authority, school governors, senior leadership team and other school staff will have no access to interviews or a list of participants.
- No mention of the school name or location of the school will be made in the research data or write-up

- The interviews will be recorded on a blackberry which is protected by a password and encryption
- The interviews will be deleted after transcription
- In the event of information being given to the researcher that indicates that a pupil may be at serious risk of abuse, or is being abused, then the school's confidentiality policy would be followed and disclosure by the researcher would be necessary
- The transcribed interviews and a code to link you to your pseudonym will be kept locked at the researcher's home for a period of 7 years and then destroyed.
- All data will be held in compliance with the Data Protection Act 1998

If this study has harmed you in any way you can contact King's College London using the details below for further advice and information:'

Chris Abbott

Reader in e-inclusion

Education Department

Franklin-Wilkins Building

Waterloo Road

London

SE1 9NH **Tel: 0207 848 3013** **email: chris.abbott@kcl.ac.uk**

Research Student Contact Details for further information:

Ann Bauer

email: ann.bauer@kcl.ac.uk

Appendix 6 Consent form for staff

CONSENT FORM FOR SCHOOL STAFF PARTICIPANTS IN RESEARCH STUDIES

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Study: An environment for maths learning: what factors improve the teaching of maths to pupils with maths learning disabilities

King's College Research Ethics Committee Ref: SSHL/13/14-23

Thank you for considering taking part in this research. Ann Bauer must explain the project to you before you agree to take part. If you have any questions arising from the Information Sheet or explanation already given to you, please ask Ann before you decide whether to

Please initial

join in. You will be given a copy of this Consent Form to keep and refer to at any time.

I understand that if I decide at any time during the research that I no longer wish to participate in this project, I can notify Ann Bauer and withdraw from it immediately without giving any reason. Furthermore, I understand that I will be able to withdraw my data up to two weeks after the interview. ☐

- **The interview will be audio-recorded and I consent to my interview being audio-recorded.** ☐

- **I consent to the processing of my personal information for the purposes explained to me. I understand that such information will be handled in accordance with the terms of the Data Protection Act 1998.** ☐

Participant's Statement:

I _____

agree that the research project named above has been explained to me to my satisfaction and I agree to take part in the study. I have read both the notes written above and the Information Sheet about the project, and understand what the research study involves.

Signed **Date**

Investigator's Statement:

I _____

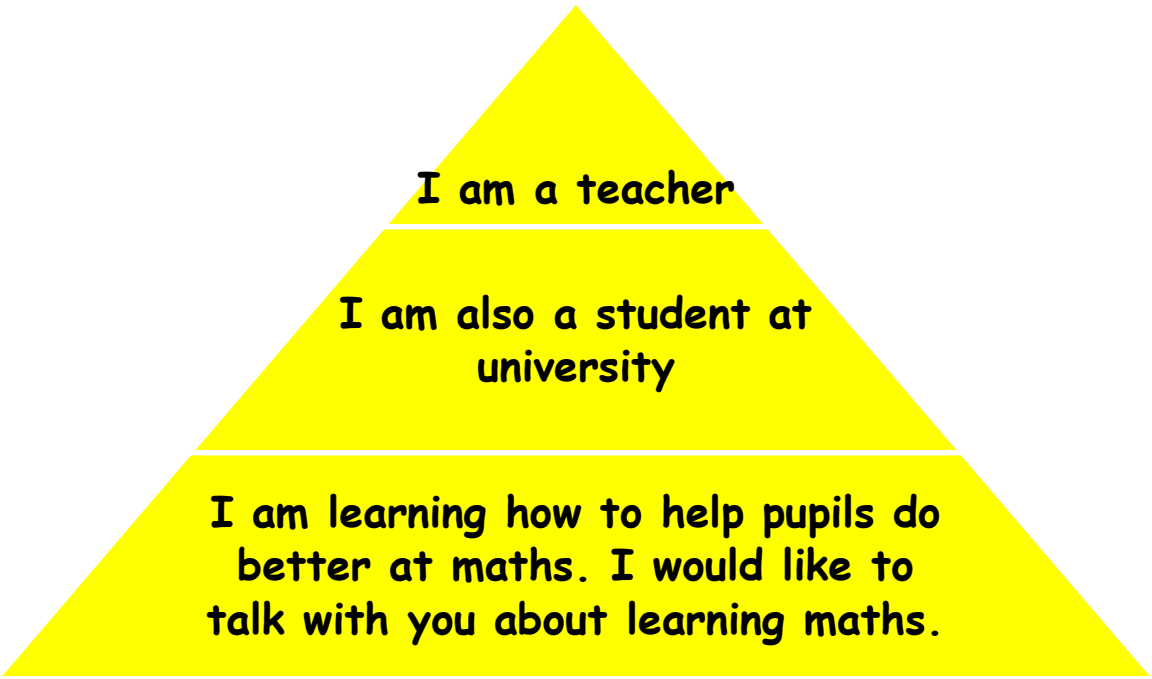
Confirm that I have carefully explained the nature, demands and any foreseeable risks (where applicable) of the proposed research to the participant.

Signed **Date**

KING'S College LONDON

INFORMATION SHEET FOR YOU from MRS BAUER

"What can help you learn maths?"



If you think you would like to talk with me please read these pages

What is the study about?	• I want to find out what is difficult and what is easy when you are learning maths • I want to find out how you feel about maths
Why have I been chosen?	• What you can tell me is very important. It will help me learn more about how to help young people learn maths.
What will happen when I talk to you?	• I will ask you some questions about how you learn maths, how you feel when you learn maths, and what you like and don't like about maths • We will talk together in a quiet room in school for about 20 - 30 minutes

How will you remember what I said?	• If you agree I will record us talking • I will write it all down later
Can I stop talking with you?	• You can stop the talking at any time • You don't have to answer any questions you don't want to • You can tell me you don't want me to write about what you said up to two weeks after our talk. • You don't have to tell me why.
Who will know what I said to you?	• A copy of my finished report will be given to the head teacher • No one will know who talked to me • I will choose a different name for you • When I write the report I will use your words but a different name

If you would like to take part then I will ask your parents to agree

If you want please contact me with any questions:

Please leave your questions with your teacher or support assistant and I will meet with you to answer your questions as soon as I can

If you feel this study has harmed you in any way you can contact King's College London using the details below:

Supervisor's name: Chris Abbott

Education Department, Franklin Wilkins Building, Waterloo Road, London, SE1 9NH

Telephone number: 0207 848 3013

E-mail address: chris.abbott@kcl.ac.uk

Appendix 8 Consent form for parents

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Study: An environment for maths learning: what factors can improve the teaching of maths to pupils with maths learning disabilities

King's College Research Ethics Committee Ref: SSHL/13/14-23

Thank you for considering allowing your son/daughter/ward to take part in this research. Ann Bauer must explain the project to you before you agree. If you have any questions arising from the Information Sheet or explanation already given to you, please ask Ann before you decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.

Please initial

I have discussed the possibility of taking part with my son/daughter/ward ☐

- **I understand that if I decide at any time during the research that I no longer wish my son/daughter/ward to participate in this project, I can notify Ann or Mrs F, SENCO, and withdraw from it immediately without giving any reason. Furthermore, I understand that I will be able to withdraw his/her data up to two weeks after the interview** ☐
- **The interview will be audio-recorded and I consent to his/her interview being recorded.** ☐

I consent to the processing of his/her personal information for the purposes explained to me. I understand that such information will be handled in accordance with the terms of the Data Protection Act 1998. ☐

- **I consent to the study** ☐

Participant's Statement:

I _____

agree that the research project named above has been explained to me to my satisfaction and I agree to take part in the study. I have read both the notes written above and the Information Sheet about the project, and understand what the research study involves.

Signed **Date**

Investigator's Statement:

I _____

Confirm that I have carefully explained the nature, demands and any foreseeable risks (where applicable) of the proposed research to the participant.

Signed **Date**

CONSENT FORM FOR PUPILS IN RESEARCH STUDIES

You have come to a meeting

1. **You have read the information sheet**
2. **You have asked all the questions you want to ask**
3. **You understand what you will be doing**
4. **If you agree to take part in an interview please will you fill in this form and give it to Mrs Bauer**
5. **Mrs Bauer will make a copy of it and give the copy to you**

Your part of the study: "What can help you learn maths?"

King's College Research Ethics Committee Ref: SSHL/13/14-23

I understand why I have been asked to take part

- **The talk will be recorded and I agree that our talk can be recorded**
- **I know that if I want to pull out I can without explaining why.**

I can pull out:

i. **Before the interview**

ii. **During the interview**

iii. **After the interview until two weeks after the interview**

iv. **I will tell Mrs Bauer or Mrs F. if I want to pull out.**

v. **I don't have to give a reason for pulling out and Mrs Bauer won't mind.**

- **I agree to Mrs Bauer using the interview for the reasons she has explained to me.**
  - **I understand that this information will be looked after carefully.**
  - **The Data Protection Act 1998 will make sure that Mrs Bauer uses this information properly.**

Please tick this box ☐

Appendix 10 Interview schedule for teachers

TEACHERS
Past experiences of learning mathematics
Current feelings about role
The current curriculum
Good/bad experiences of teaching mathematics
Enjoyable aspects of teaching maths Difficult aspects of teaching maths
Methods used
Use of tools
Role of teacher and LSA
Relationships between pupil behaviour and progress in mathematics
Three wishes

Appendix 11 Interview schedule for LSAs

LSAs
Past experiences of learning mathematics
Current feelings about role
The current curriculum
Good/bad experiences of supporting mathematics learning
Enjoyable aspects of supporting Difficult aspects of supporting
Methods used
Use of tools
Roles of teacher and LSA
Relationships between pupil behaviour and progress in mathematics
Three wishes

Appendix 12 Interview schedule for pupils

PUPILS
Book look: *talk about anything pupil is proud of or wants to tell me about*
Hard /easy interactive board: choice of topic cards symbols or words
Something learned well/fun to do: *use topic cards, narrative and/or demonstration if pupils wishes* Something difficult: *use one of chosen 'hard' topic cards, narrative and/or demonstration* *Return to in what makes mathematics hard if relevant*
Experiences of support: *Card of support learner with assistant/teacher, place on Likert scale of helpfulness, narrative, can refer to emotions cards*
Use of tools for learning mathematics: *picture card of tools, some concrete tools, Likert scale for usefulness, narrative/demonstration of use if wished, refer to emotions cards*
What makes learning mathematics hard: interactive *Cards referring to mathematics related problems, and what helps, for example:* *Language, pace, remembering, unhelpful emotions, understanding* *Learning words, having more time, having help, working in groups or with a partner* *And classroom setting:* *someone available to help, noise, learning partner or group, availability of tools*
Feelings: interactive *emotions with symbols to choose from to identify feelings, positive and negative offered: worried/excited sad/happy embarrassed/proud confused/confident bored/interested/listening crying/pleased angry/relaxed*
Three wishes